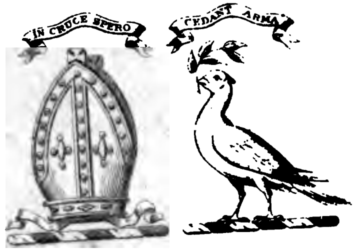
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PROCEEDINGS

OF THE

GEOLOGISTS' ASSOCIATION.

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VOLUME THE SECOND.

1870–1871.

(Authors alone are responsible for the opinions and facts stated in their respective Papers.)

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LIST OF ILLUSTRATIONS.

PROCEEDINGS

OF THE

GEOLOGISTS' ASSOCIATION.

ORDINARY MEETING, February 4th, 1870.

Professor Morris, F.G.S., President, in the Chair.

The following paper was read :—

"On Graptolites." By William Carruthers, Esq., F.L.S., F.G.S., Honorary Member of the Geologists' Association.

(The publication of this Paper is deferred.)

ORDINARY MEETING, March 4th, 1870.

C. T. Richardson, Esq., M.D., Vice-President, in the Chair.

The following paper was read :—

"On the Strata exposed by the Line of Railroad through the Sevenoaks Tunnel." By Caleb Evans, Esq., F.G.S.

(Abstract.)

The author described in detail the various deposits passed through in constructing the tunnel (3,451 yards in length), under the range of hills on which Sevenoaks is situated, and the sections seen in the cuttings to the north of that tunnel.

The lowest beds traversed by these works are of fresh-water origin, are only seen in the neighbourhood of Sevenoaks Weald, and consist of grey, blue, and greenish clays, with many layers of flattened bivalve shells of the genera Unio and Cyrena. Many of the layers are studded with great numbers of Cyprides mostly as casts in the clay. Detached fish-scales are dispersed throughout this group of beds, the rhomboidal scales of Lepidotus being the most abundant.

Finely preserved specimens of the palates of fishes exhibiting two or three different kinds of crushing teeth, and also reptilian and other vertebrate remains have been here obtained.

At the bottom of shaft No. 3, at a depth of 127ft. from the surface, is a band about 2ft. thick of hard Sussex marble, consisting almost entirely of the shells of Paludina, and occasionally of Cyrena. A few scales, palates, and other fish-remains are met with in this rock.

A short distance above this band of limestone, beds of green, buff, and brown clays set in. Some of these clays are excessively hard and dry, almost approaching to a slaty character. Fossils are rare in these beds, but a few specimens of Unio have been met with.

At the shafts on Sevenoaks Common, at the top of the hill, higher beds of the Weald clay are seen, in which the numerous bands of Unio give place to layers of Cyrena. In this portion of the series there are many concretionary masses, containing seams, often thin, but occasionally two or three inches thick, composed almost entirely of the valves of Cyrena—the shells in some blocks being of large size, in others smaller and associated with a small turreted shell. In some blocks are layers of a small Paludina. Others present surfaces studded with the shell cases of *Cypridea tuberculata* in a fine state of preservation.

Detached scales, vertebræ, and spines of fishes are plentifully dispersed throughout most of these concretions, and in one of these Mr. Bott found a beautiful specimen of Lepidotus. A large block of stone from this part was observed by the author presenting on the surface a well-defined outline of a turtle. The bones unfortunately were much broken. The specimen was depressed and elliptical in form, about a foot in its longest diameter, and the surfaces of the bones were smooth.

The highest bed of the Weald clay consists of a dark, almost black, clay, which shows the first transition from fresh-water to marine conditions, the prevailing fossils in it being Cerithia or Potamides, and with them are associated an Ostrea, a Cardium, and a few other shells of an estuarine or marine character.

The succeeding bed is a dark greyish-coloured sandy clay, which gradually passes, by the loss of argillaceous matter, into a dark clayey sand, and this upper portion contains a vast amount of water, which was a source of much difficulty to the excavators.

These beds contain concreted masses of large size, and abounding with shells. The most conspicuous and abundant fossil in the concretions is the *Perna Mulleti.* A large oyster, or Gryphæa, is also very common. Many other shells, chiefly bivalves, are present both in the concretions and in the softer portions of the bed, nearly all agreeing with those given in the published lists of the fossils of the lower beds of the greensand, at Atherfield. Among the most abundant are *Corbula striatula*, *Arca Raulini*, *Myacites plicata*, *Nucula scapha*, *Terebratula sella*, and *Trigonia caudata.* The thickness of these "Atherfield beds" is estimated at about 50ft.

The dark-coloured beds are succeeded by the Kentish Rag series, consisting of alternations of hard bands of limestones, sandstones, and chert, with the softer Hassock stone.

The relation of the upper portion of the lower group to the Kentish Rag, or "Hythe series," is well seen in the cutting at the northern mouth of the tunnel. The direction of the cutting at this point is from N.W. to S.E., and is not quite in the direction of the dip of the beds, which is nearly south. The lower part of this cutting consists of the sandy Atherfield bed, of a dark blue colour, above which the Kentish Rag series appears rising from the south at an angle of about 25°. The bands of stone being of a yellowish or ochreous tint, the marked difference in colour between them and the blue Atherfield bed renders the junction very conspicuous. The outcrop of the softer lower series occupies a small irregular valley between the hills, but at a short distance from the mouth of the tunnel the blue bed is suddenly cut off by a very conspicuous fault, on the north side of which the Ragstone beds again appear, and are seen in the sides of a deep cutting. They are here nearly horizontal, but are somewhat turned up and rubbly at the line of contact with the fault. On the east side of the cutting the section is somewhat different. The stone beds rise at a steep angle from the mouth of the tunnel, but the lower layers before reaching the surface of the country are suddenly bent down at a sharp angle to the north, and after dipping for a short distance curve round to the surface near the lowest ground of the valley. The stone beds also curve up to the surface on the north side of the fault, but soon become horizontal.

The Ragstone series consists of about 20 bands of stone, separated by softer bands of sandstone with green grains, known as Hassock. The beds become more sandy in the upper portion of the section. The Ragstone beds are about 100ft. thick.

The fossils of the Kentish Rag group are found, for the most part, in the Hassock. The most abundant are *Lima Cottaldina*, D'Orb, and *Trigonia spinosa* var., Sow. (*T. ornata*, D'Orb.). *Terebratella oblonga* Sow., and a Plicatula are occasionally found.

After crossing a valley, the line, near Riverhead, cuts through another ridge entirely composed of the highest portion of the Lower Greensand, consisting of yellow and ferruginous sands, with no trace of stone except irregular bands and veins of pebbly ironstone, and devoid of fossils; and the line then passes over the broad valley of the Gault.

In conclusion, the author noticed the conditions under which the Sevenoaks deposits had been formed, and also the British and Foreign equivalents of the beds.

VISIT TO THE BRITISH MUSEUM.

On Wednesday, March 23rd, 1870, a party of the Members of the Association visited the British Museum for the purpose of inspecting the Geological Department, when brief descriptive lectures on various portions of the collection were delivered by the President, William Carruthers, Esq., F.G.S., F.L.S., Henry Woodward, Esq., F.G.S., F.Z.S., Professor Tennant, and Edward Charlesworth, Esq., F.G.S.

ORDINARY MEETING, April 1st, 1870.

C. T. Richardson, Esq., M.D., Vice-President, in the Chair.

The following paper was read:—

"On Volcanos." By Henry Woodward, Esq., F.G.S., F.Z.S.

In whatever part of the world we live we can readily discover, by ordinary observation, that there are two great forces constantly occupied in remodelling its surface, from year to year, from century to century.

Little of what they are now doing can be noted by us in our lifetime, or even in the lifetime of our race; but as they have ceaselessly laboured since our planet came into existence, we can, by examining the marks they left long since, find out what each is now doing, and what they can achieve together, for then they are most potent.

These two mighty forces, Upheaval and Denudation, are represented by Fire and Water.

"The gentle rain which cometh down from heaven" is ever occupied in the task of washing away, grain by grain, the dry land, and every brook and river ceaselessly carries on the same task; whilst the sea, on every coast-line, continuously attacks the bordering cliffs until they succumb to its resistless force.

Indeed, if water acted as the servant of denudation only, the earth would have but a poor chance of keeping her head above water; but far down beneath the earth where dwell the dethroned Titans, and where Vulcan forges the thunderbolts for Jupiter (so at least we learnt at school), it seems undeniable that the temperature is so exceedingly high that any water happening to lose its way (as water is apt to do in the dark among so many chinks, crannies, and cracks), and getting down beneath its proper level, is immediately seized by fire, and before it can escape into the bright air it is compelled, as steam, to lift earth-weights, which probably, when all are put together, amount to as much or even more than the drop of water ever did above-ground in the service of denudation.

What do we know of the interior of the earth? How far has man been able to pry into the inside of the great revolving ball upon the outside of which he is being carried around in London at the rate of 600 miles per hour?

Here is a diagram to illustrate and answer this question. (Fig. 1.)

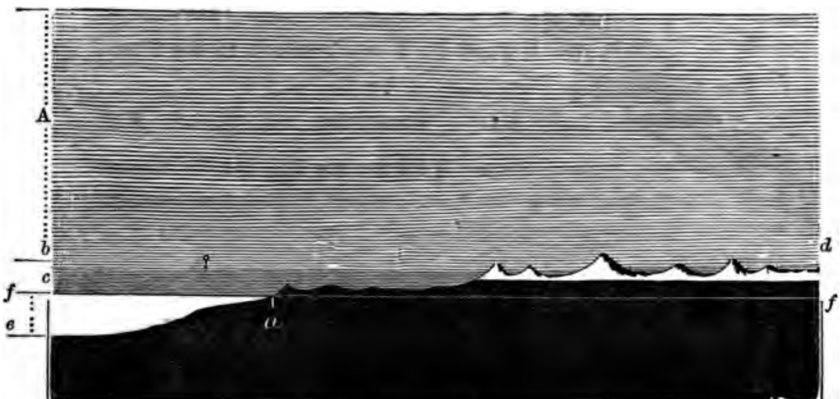

Fig. 1.—Height and Depth.

Explanation of Diagram.

A. Atmosphere taken at 50 miles.

c. Half the pressure of which is shown at five miles.

d. Mount Everest, the highest known land of the world in the Himalayas, 29,000ft.

a. Deepest mines, Stassfurt, in Germany, and Monkwearmouth, Sunderland (about 2,000 feet).

b. Highest balloon ascent, Messrs. Glashier and Coxwell, 1862—6½ miles.

e. Deepest sounding in the ocean, Lat. 36° 49′ S., Long. 37° 6′ W. Soundings were found at a depth of 7,706 fathoms or 8¾ miles. (A. Keith Johnston's Physical Atlas).

f. f. Sea Level.

From *f.* to *k.* represents a vertical depth of 50 miles

This diagram represents 50 miles only out of the 3,962 miles from the exterior to the centre, which would require a diagram nearly 80 times as long to express. From this we can easily perceive that unless we watch Nature's great agents at work, and take note of her records, we should know next to nothing of the interior of our globe. We are, in fact, reduced to make the same kind of observations which led Columbus to discover the New World; we must watch the waifs and strays thrown up by the tide from this great unknown region, 7,925 miles across which divides us from the Antipodes.

The evidences afforded of the condition of the earth's interior are derived from :—1, volcanic products; 2, thermal springs; and 3, the observations we are enabled to make of underground temperatures.

The rocks at the surface of the earth are everywhere roughly divisible into Igneous and Sedimentary, *i.e.*, produced by the agency of fire and water. Igneous deposits, like sedimentary beds, often show stratification, often, too, they are arranged by water under the sea.

The Sedimentary rocks are all deposited by water, either in lakes, rivers, or in seas.

All over the world one meets with conical-looking mountains, frequently surrounded, more or less completely, by an outer and larger circle of cliffs, and having a crater-formed hollow within. (Fig. 2.)

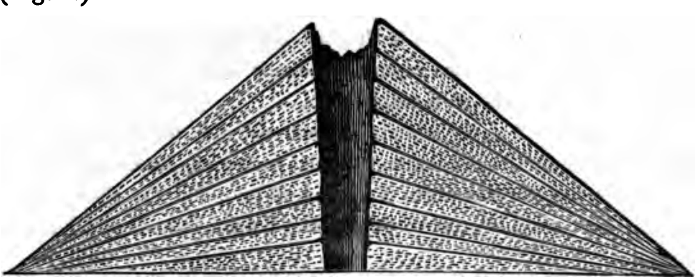

Fig. 2—Ideal Section of a Volcano.

When we examine their structure we find they are composed of sloping layers of ashes, cinders, stones, pumice, and other loose materials interstratified with beds of lava and other matter, evidently forced up in a fluid state from within.

Some of these mountains are still active, and by seeing what goes on at their openings one can more readily understand the origin of other similar hills now long since silent.

Taking a map of the world we can trace out upon it roughly the chief volcanic regions where active eruptions are going on or have been seen in historic times.*

Upwards of 400 volcanic mountains are known to exist in various parts of the earth, more than half of which have given evidence of activity in modern times.

They are distributed over—

	Extinct.		Active.
Europe...	7	......	5
Atlantic Islands	14	......	8
Africa...	8	......	1
Continental Asia	25	......	15
Asiatic Islands	189	......	110
Indian Ocean...	9	......	5
South Sea	40	......	26
America	120	......	56
	407		226

In Europe we have Ætna, Vesuvius, Stromboli, Volcano, and Santorin (active); Ischia and Phlaegræan Fields (historic); Auvergne (prehistoric).†

In Africa, the Cameroons Mountains, on the West Coast, and others on the Red Sea Coast, and in the Comoro Islands.

India has no burning mountains; but Barren Island, in the Bay of Bengal, Bourbon, and the remote Island of St. Paul, are active volcanos.

In Asia the only volcano is that of Demavend, on the shores of the Caspian Sea, and two reputed volcanos in the Thian-shan, and nine in the peninsula of Kamtschatka.

Through the Asiatic islands a great volcanic belt extends from Birmah through the Andaman Islands, Sumatra, Java, and Timor, thence turning northwards to Amboina, Gilolo, and the Philippines, then by Loo-choo Islands to Japan, the Kurile Islands and Kamtschatka.

Here in this region there are above 100 active volcanos.

Through the South Sea Islands, whenever any rock is visible it

* For a world-map of volcanos see Scrope's invaluable work on volcanos; see also Keith Johnson's Physical Atlas.

† In Auvergne, on the side of Mount Denise, near La Puy, two human skeletons were found, together with bones of Elephas, Rhinoceros, Cervus, &c., imbedded in volcanic matter, showing that man in his early state was in the country prior to the extinction of these craters. (Scrope).

is of volcanic origin, but in all this great region there are fewer smoking volcanos than on the single island of Java. The active vents occur in the Sandwich Islands, New Guinea group, New Hebrides, and New Zealand, and in the Friendly Islands.

The Western Coast of America, from the Aleutian Islands and the recently ceded Russian American territory to the southern extremity of the continent and Tierra del Fuego, presents the most stupendous line of volcanic rocks, cones, craters, and other indications of subterranean phenomena in the whole world. One-fourth of the known active volcanos are found in it. No volcanos are found on the eastern coast of America, but in the West Indies there are three active vents in the Lesser Antilles.

Volcanos occur mostly in tropical regions, few exist more than 30° from the equator, but to this rule there are exceptions; for amid Arctic and Antarctic snows blaze forth—

Jan Mayen (6,874ft.), at the North Pole.
Hecla in Iceland (5,110ft.) „
Mount St. Elias (17,860ft.), North America.
Kamtschatka (15,763ft.), in North Asia.
Taranaki, New Zealand (8,840ft.), in the South Sea.
New South Shetlands „ „
St. Paul „ „
Erebus, South Polar Land (12,400ft.), Antarctic.

The products of volcanic action are most various,* and are either thrown into the air by the explosive gases and vapours which accompany a volcanic eruption, and fall as dust, ashes, scoriæ, and stones; or are poured out in a stream of melted rock from the summit, or more generally the flanks of the volcano.

In consequence of the explosive force being directed nearly vertically, and the ashes falling on all sides equally round the aperture, the hills of scoriæ, ashes, &c., accumulated round a volcanic vent,

* The following gaseous and other products have been observed as emanating from volcanos:—

Steam.	Ashes.
Sulphuretted Hydrogen.	Pumice.
Sulphurous Acid.	Sand.
Carbonic Acid.	Lapilli.
Nitrogen.	Scoria.
Chloride of Sodium.	Bombs.
Chloride of Potassium.	Vescicular Lava.
Chloride of Ammonium.	Obsidian.
Sulphur.	Basalt.

are always conical. Whether lava-currents issue from the apex or the side, they merely cause a slight irregularity in figure; but a new explosive vent, opening towards the base of the mountain, may throw up a new hill. (See Fig. 4, p. 11.) Thus several cones on the flanks of Etna have been thrown up in the Val del Bove, a great excavation in the side of its cone.

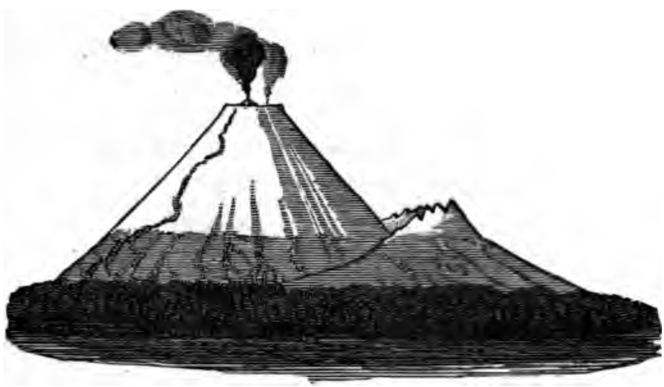

Fig. 3.—Cone of Cotopaxi; seen from a distance of 30 miles.

The cone of Cotopaxi (18,875ft. in height above the sea), in the Andes of Peru (Fig. 3), is an example of this extreme and beautiful regularity on the largest and most striking scale. The drawing from which this sketch is made was taken by Godfrey Vigne, Esq., who visited the spot a few years ago.

Another instance is that of the cone of Mount Wellington, near Auckland, New Zealand. (Fig. 4, page 11.)

But we have many craters without cones. The crater of Kilauéa, in Hawaii (Fig. 5), exhibits, on a much larger scale than any other active volcano, a lake of liquid lava four miles in diameter, more or less crusted over on the exposed surface, through which at several points volumes of vapour burst upwards with jets of highly viscous matter, which, on cooling take the form of vitreous filaments or scoriæ. (See Woodcut, Fig. 5, page 11.)

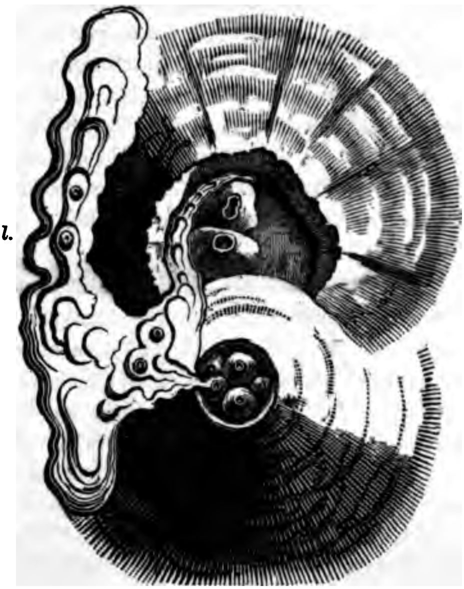

Fig. 4.—Bird's eye view of Mount Wellington, near Auckland, New Zealand. (From Hochstetter's New Zealand.)
(*a*) Ancient cone, partly destroyed by (*m*) modern cone, which has sent forth the lava-stream (*l*).

This is a flanking-crater to the old volcanic cone of Mauna-Loa. It is 4000 feet above the sea, and about four or five miles in its longest diameter. The whole mass is never agitated, save before a

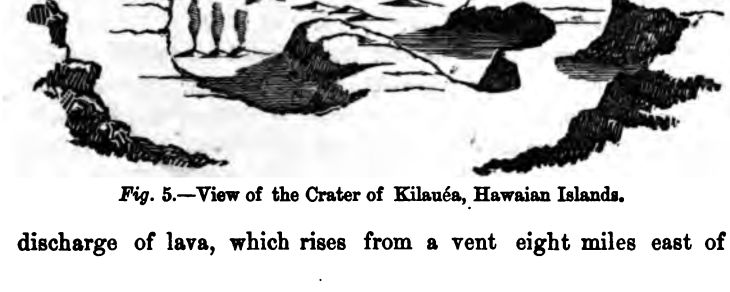

Fig. 5.—View of the Crater of Kilauéa, Hawaian Islands.

discharge of lava, which rises from a vent eight miles east of the great basin, and descends in a rapid manner for 4000 feet to the sea. In 1840 it flowed at the rate sometimes of five miles per hour! The ordinary rate is less than half a mile.

It boils up in this enormous cauldron-like lake often 15 feet above the rim and cascades over in places; but being very viscid, this seldom occurs. Pools and lakes of fluid lava cover the surface, and craterets 30 or 40 feet high also are seen emitting vapours and lava. The date of the last eruption was 1868.

In visiting Kilauéa in 1864, Mr. T. Brigham writes:—*

"As soon as our men came up with the blankets, we engaged guides, and went down into the crater. The descent was steep and winding, and we passed over several terraces, which were the result of a sinking or falling in, as they were inclined and much broken, and came under the grand pali of compact lava. A descent of more than 400 feet brought us to the bottom, and we stepped from a gravelly shelving bank on to a black lava which had broken out last year under the north bank, and overflowed this end of the crater Where it touched the gravel bank it had glued to its under surface the small fragments of stone, but had not altered their appearance, and all along the edge it was cracked and laid up on the bank as if, on cooling, the lava had fallen about a foot.

"The surface was covered with a thin scaly vitreous crust, which crumbled beneath the tread, sounding like snow on a cold morning, and thus a very distinct path was made to Halemáumau, the enduring house of the Goddess Pélé.

"The lava beneath this crust, however, was so hard as to give out abundant sparks as the nails in my shoes scratched upon it. When hard it was often iridescent, like some anthracite coal, and so closely resembling this mineral that the difference would hardly be detected by a cursory examination. The fresh lava exactly resembled that from Mauna Loà in the flow of 1859.

"Three-quarters of a mile over this uneven lava, and we came to a long wall composed of fragments of all sizes and shapes, very solid and heavy, and full of small grains of olivine; and this wall, which is concentric with the main wall of Kilauéa, is said to rise

* Boston Academy of Natural Sciences, U.S. America.

and fall, and sometimes disappear, which seems to be a fact, although no one has ever seen it in motion.

"It is the fragments broken from the edge of the crater by an eruption, and floated out to their present position.

"An unpractised eye would see no marks of fire on the rough, granite-like masses.

"Caves, cracks and ridges make the surface very uneven, and after walking two miles we came to several large cracks of great depth, but not more than a yard wide, and then a wall enclosing an amphitheatre, down which we climbed on the loose slabs of lava.

"When we were near the Halemáumau, we came to a cone formed of spattered lava and cemented scoriæ, some 25 feet high, with a bright light at its apex; this was the first fire we had seen, but we passed by, eager to reach the great lake. This we accomplished after ascending a gradual incline.

"It was about 800 feet in diameter, and the lava was 50 feet below the cliff on which we stood, covered with a dark crust, which was broken around the edges, and there the blood-red lava was visible, surging against its walls with a dull, sullen sound. The smoke was blown away by the wind, so that we were able to stand on the very verge of the pit, but the heat was so great that we were obliged to hold our hands before our faces. The walls on which we stood, and where we intended to sleep, were thickly covered on the side towards the pit, with waving woolly Pélé's hair, which we saw forming continually.

"The drops of lava thrown up drew after them the glass thread, or sometimes two drops spin out a thread a yard long between them, and the 'hair' thus formed either clings to the rough sides, or is blown over the edge where it catches on any projecting point.

"The drops are always black, or a very dark green on the surface, but light green within, porous, and excessively brittle, and the thread is transparent, and when first formed of a yellow or greenish colour.

"Occasionally a crack would open across the lake, and violent ebullitions commence at various points of its surface.

"There were two small islands in the lake, which the lava seemed seeking to destroy.

"The current would often set in towards the banks, and it appeared as if the whole mass was about to be drawn in, as cake after cake broke off from the surface and disappeared, but it would soon cease, and then run towards another point of the wall, and I could not see that it was oftener on one side than another.

"As a cake of lava parted from the crust, the red lava rose above the crack, running on the surface, and as the crack grew wider, cooling rapidly, and being drawn out much like molasses or candy.

"Whilst white hot, the lava was as liquid as water, but it rapidly assumed the viscid condition, and then the solid. I threw a stick of dry wood on the surface, which instantly became fixed, after a violent bubbling, and it was ten minutes before any smoke appeared, and it was only when a crack opened under it that it was consumed.

"The motion was always from the centre, except when the lava was thrown back in spray from the caverns which extended under much of the wall.

"We laid down in our blankets on the eastern edge, where the walls were highest (and the wind drove away the smoke), and here soon fell asleep.

"About nine o'clock I got up and moved to the very edge of the pit to view the molten mass to better advantage, and warm myself, as the wind was quite cold. The moon was up and almost full, but her orb was pale beside the fires of Pélé.

"Finding the place quite comfortable I lay down and went to sleep. At twelve I awoke with a start, and found myself in the midst of a shower of fiery drops, some of which were burning my blanket. I shook myself and jumped back, looking at my watch to note the time, for I thought a great eruption at hand, and then stood gazing at the strange scene for some time before I thought of calling my companions.

"The whole surface of the lake had risen several feet, and was boiling violently and dashing against the sides, throwing the red-hot spray high over the banks, causing the Providential rain of fire which awoke me to see this grand display. There was no noise, except the dash and sullen roar. When I could think of anything else I called the others, who were asleep several rods from me, but I only succeeded in awakening the guides, and just then a drop came plump on to a greasy paper we had brought our supper in, and it blazed up so suddenly that one of the Kanakas thought it a new jet opening at our feet, and ran off to some distance.

"Failing to arouse my companions by calling, I threw a handfull of small stones at them, but without effect, and I had to climb down and shake them roughly. When they had got to the edge, the action had greatly diminished, and in a few minutes more the dark crust again covered the central portion, and we all went to sleep."

If we compare the Islands of Santorin with those of Hawaii, we shall readily be able to perceive a striking resemblance between the two groups. (Figs. 6 and 7.)

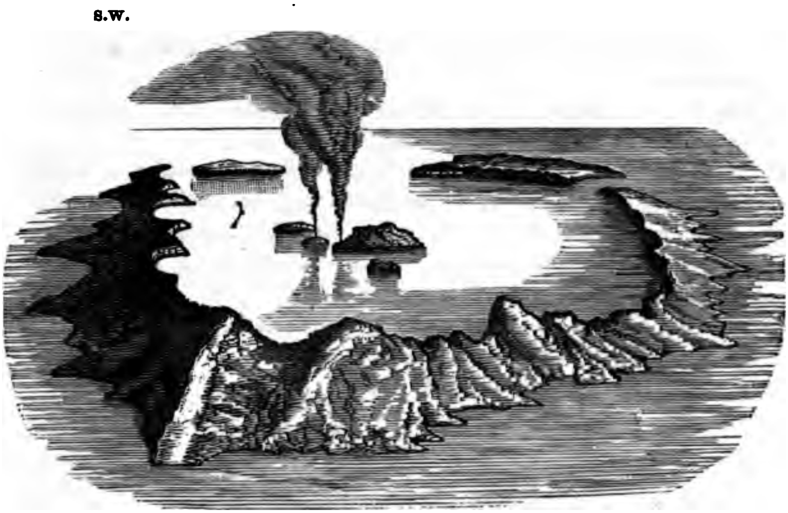

Fig. 6.—Islands of Santorin (after Lyell) with the volcanos on the Islands of Aphroessa and George in a state of eruption, February, 1866.

Fig. 7.—Ideal Section of Santorin in a N.E. and S.W. direction.
A. Aspronisi. O. Old Kaimeni. N. New Kaimeni. L. Little Kaimeni.
T. Thera.

Santorin was in active eruption so lately as in 1866.

We may also compare the Island of Thera with that of St. Paul.

Graham's Island is another illustration of a sub-marine volcano. This island made its appearance July 10th, 1831, off the South West coast of Sicily. It was then 12 feet above water; on the

10th of August it had attained the height of 800 feet; but being composed of loose scoriæ and cinders, and having no lava to solidify its cone, it began to be rapidly destroyed and washed away by the sea, and has now entirely disappeared.

Volcanic Products.

Volcanic products may be roughly divided into solid, liquid, and gaseous.

Of the solid matter thrown out from volcanic vents may be enumerated "Volcanic Bombs," "Scoriæ" (or cinders), "Lapilli" (or gravel), "Puzzolana" (or sand), "Pumice," and "Ceneri" (ashes).

Of the liquid matter poured out, either from the crater itself or from rents in its sides, we have the substance called "Lava," which, when solidified, may be either Basalt, Obsidian, or Vescicular Lava, depending upon the condition under which it cools, or the temperature at which it is ejected.

Basalt is lava solidified under pressure; it frequently presents the condition of "Columnar Basalt," as in the Auvergne, Staffa, Antrim (Fig. 8), New Zealand, &c.

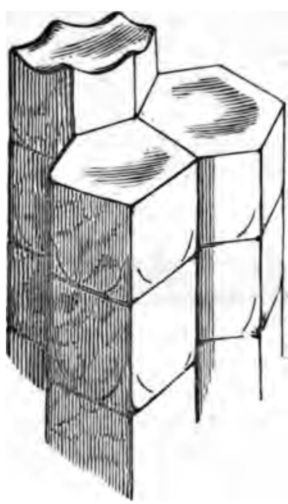

Fig. 8.—Basaltic columns from the Giant's Causeway. In the apartments of the Geological Society, Somerset House.

The most glassy and semi-translucent varieties of lava are known by the name of "Obsidian," or "Volcanic Glass," and occur abundantly in Iceland, the Lipari Islands, Mount Ararat, and Mexico.

Large tracts in Mexico (called Malpais) are covered with "Obsidian," and of it—as from the chalk-flints in western Europe and Britain—the worshippers of the sun manufactured their knives, &c., which were still in use at the time of the Spanish conquest (1518).

Of the gaseous emanations from volcanic vents may be enumerated sulphuretted hydrogen, sulphurous acid gas, chlorine, nitrogen, and carbonic acid gas.

But water, as steam, is certainly the most abundant substance present, as it is also the most active agent in all volcanic outbursts, and may even be (as Mr. Scrope has supposed) the cause of the flow of lava streams. We know that, in cooling, lava gives off an immense volume of steam, and also that the vesicular cavities in lava are caused by it.

In all volcanic eruptions water appears to be present also in a liquid state, and is frequently ejected during volcanic eruptions in vast quantities. This may arise from three different causes:—

(1) It may be ejected from the earth's interior with other volcanic matter; or,

(2) From the melting of snows on the sides of the crater; or,

(3) By the discharge of rain-water accumulated in the crater during a period of repose.

The volcano of d'Agua in Guatemala is a perfectly circular cone, more than 11,000 feet high. From it descended, in 1541, a torrent of water (the contents, no doubt, of a crater-lake on the summit), which destroyed the old town of Guatemala, since removed to a new site.

Living fish and alligators were observed in a crater near the lake of Nicaragua, by Dr. C. Carter Blake.

Wherever the tropical rainfall is large, or the height of the mountain condenses the snows upon its sides and crater, an eruption is sure to be preceded by a "mud débacle;" miles of country are thus devastated and destroyed.

Kilauea, Central America, South America, and Java will illustrate this.

In 1755 Etna sent a sudden flood of water into the Val del Bove, the volume of which in one mile was estimated at 16,000,000 cubic feet.

Of the magnitude of lava streams, that which burst forth from the Skaptár Jokul in Iceland, in 1783, continued to flow for two years.

It filled up the rocky beds of rivers to a depth of 600 feet by 200 feet wide, and spread out in the plains 12 to 15 miles wide, and 100 feet deep! The two principal streams were respectively 40 and 50 miles in length, forming a mass surpassing Mont Blanc in magnitude.

The waters of springs being suddenly converted into steam formed craterets over the lava stream 30 feet high. (Fig. 9.)

Fig. 9.—Craterets on the lava-stream of 1783. Skaptár Jokul, Iceland.

Heat may be retained by lava streams for 20 years in parts.

From the crater of Galongoon, in Java, in 1822 (after an earthquake shock), was vomited out immense columns of boiling water, mud, steam, brimstone, ashes, and lapilli in such mass and with such violence as to fall 40 miles distant. The valleys were all filled; 24 square miles were covered to a depth of more than 100 feet (in places) with hot blue mud, burying houses, villages, and people.

The second eruption followed (preceded by terrific rains), accompanied by hot water and mud, and great blocks of basalt were thrown seven miles!

One side of the crater was rent away, new hills and valleys were formed, and two rivers changed their courses.

In one night 2,000 persons were killed; altogether the official return shows 114 villages destroyed, and above 4,000 persons killed.*

In January, 1803, all the snows were dissolved off Cotopaxi in one night, causing vast deluges of mud to descend, with great destruction to the region around.

The deluges caused by lake-craters probably exceed in magnitude and destructiveness those of lava-streams.

* Van der Boon Mesch, in Lyell's "Principles of Geology." Vol. ii., p. 56.

In 1797 a mud-debacle poured from Tunguragua, in Quito, filled a valley 1,000 feet wide to the depth of 600 feet.

Many small fish were observed enveloped in the mud. No doubt the fossil fishes and insects found at Oeningen were brought down from an old crater-lake by a Miocene volcano.

Similar deposits, also of volcanic origin, rich in fossil fishes, are found at Aix, in Provence.

The volcano of Imbaburu, in 1691, vomited forth so many fishes that it bred fever, from the stench caused by their decomposition, and that of other animals destroyed by the debacle.

The distance to which the sound of volcanic explosions is transmitted, and the fine ashes scattered by the currents of the air is truly wonderful.

" On the night of 30th April," writes Professor Dove,* " explosions like those of heavy artillery were heard at Barbadoes, so that the garrison at Fort St. Anne remained all night under arms.

" On May 1st, at daybreak, the eastern portion of the horizon appeared clear, whilst the rest of the firmament was covered by a black cloud, which soon extended to the east and quenched the light there, and at length produced a darkness so dense that the windows in the rooms could not be discerned.

" A shower of ashes descended, under which the tree branches bent and broke.

" Whence came these ashes? From the direction of the wind we should infer that they came from the Peak of the Azores; they came, however, from the volcano of Morne Garou, in St. Vincent, which lies about 100 miles west of Barbadoes.

" The ashes had been cast up with such force as to enter into the current of the upper trade-wind.

" A second example of the same kind occurred in January, 1835. On 24th and 25th the sun was darkened in Jamaica by a shower of fine ashes, which had been discharged from the mountain Coseguina, 800 miles distant. The people learned in this way that the explosions previously heard were not those of artillery.

" These ashes could only have been carried by the upper current, as Jamaica lies north-east from the mountain.

" The same eruption gives also beautiful proof that the ascending air current divides itself above, for ashes fell upon the ship

* Dove Prof. Witterungs Verhaltnisse von Berlin, in Tyndall's "Heat as a Mode of Motion," p. 166.

Conway, in the Pacific, at a distance of 700 miles south-west of Coseguina.

"The roaring of Coseguina was heard at San Salvador, a distance of 1,000 miles.

"Union, a seaport on the west coast of Conchagua, was in absolute darkness for 43 hours; as light began to dawn it was observed that the sea shore had advanced 800 feet upon the ocean, through the mass of ashes which had fallen.

"The eruption of Morne Garou, forms the last link of a vast chain of volcanic actions accompanied by earthquake shocks.

"In June and July, 1811, near San Miguel, one of the Azores, the island Sabrina rose, accompanied by smoke and flame, from the bottom of the sea, 150 feet deep, and attained a height of 300 feet and a circumference of a mile. The small Antilles were afterwards shaken, and subsequently the valleys of the Mississippi, Arkansas, and Ohio, but the elastic forces found no vent; they sought one, then, on the north coast of Columbia.

"March 26th began as a day of extraordinary heat in Caraccas; the air was clear and the firmament cloudless.

"It was Green Thursday, and a regiment of troops of the line stood under arms in the barracks of the quarter of San Carlos, ready to join in the procession. The people streamed to the churches. A loud subterranean thunder was heard, and immediately afterwards followed an earthquake shock, so violent, that the church of Alta Gracia, 150 feet high, borne by pillars 15 feet thick, formed a heap of crushed rubbish not more than 6 feet high.

"In the evening the almost full moon looked down with mild lustre upon the ruins of the town, under which lay the crushed bodies of upwards of 10,000 of its inhabitants.

"But even here there was no exit granted to the elastic forces underneath.

"Finally, on April 27th, they succeeded in opening once more the crater of Morne Garou, which had been closed for a century, and the earth, for a distance equal to that from Vesuvius to Paris, rung with the thunder-shout of the liberated prisoner."

The eruption of Vesuvius, in 1794, was the most formidable known in the history of this truly classical crater.*

* A most valuable and interesting account of Vesuvius was read before this Society by the now Honorary Secretary, J. Logan Lobley, Esq., F.G.S, in 1868, giving not only its history, but a description of a personal visit paid during the last eruption. This has since been published in a separate form, by E .Stanford, Charing Cross, with illustrations, and a list of all the minerals both of Somma and Vesuvius.

On the evening of June 15th violent earthquake shocks were felt, and a sudden outburst of lava in the Pedimentina, among the remains of the earlier currents, occurred at two, p.m. A fissure 2,375 feet long was produced, from which the lava issued for the space of 237 feet in breadth, throwing up four crateriform cones, each of which ejected red-hot stones in quick succession, so as to appear like one continuous outburst. The showers contained really fluid lava (similar to the lava fountains seen in the Hawaian Islands).

The lava issued from 15 mouths, and ran towards Portici and Resina in two streams, and the inhabitants of Torre del Greco (whilst sorrowing for their neighbours) rejoiced, and gave thanks in the churches for their own escape.

But these two streams stopped short, and the main body, after all, rushed towards the sea, right through the poor town of Torre del Greco (which had hoped to escape), presenting a fiery front of 1,500 feet. It continued, and entered the sea, advancing into it until the 17th inst.

The distance from the outlet to the sea margin is 12,961 feet, which was traversed by the lava in six hours.

The following is a list of some of the eruptions of Vesuvius:—

Sixty-six eruptions occurred from A.D. 79 to 1868. Of these the first, in A.D. 79, was the great historical eruption when Pliny the elder lost his life, and half of the old crater of Somma was blown away. It was this which destroyed Herculaneum, which now lies buried under six outbursts of ashes, liquid mud, and lava. It is situated under the modern town of Resina, and harder to dig out than Pompeii which was overwhelmed by an eruption of dry ashes and lapilli. Stabiæ, the furthest distance removed, was buried, but not so utterly destroyed, by an eruption of dry ashes and lapilli only. Pliny the younger witnessed this eruption.

A.D. 472.—Ashes from Vesuvius were spread over Europe as far as Constantinople, causing terror to the inhabitants, who keep up the anniversary on the 8th of November.

A.D. 1631. Darkness, and great agitation of the sea. Ashes fell at Constantinople. Torrents of rain and mud descended, with stones, ashes, and vapour, accompanied by seven streams of lava. Torre del Greco, Resina, Granatello, and Portici, were all destroyed, and 18,000 persons are said to have perished.

A.D. 1822. 800 feet of the modern cone was blown away, and a great discharge took place of ashes and vapour.

For further accounts of Vesuvius, see Scrope's grand works on volcanos, and Prof. Phillips' and Mr. Lobley's works on Vesuvius.

To these and to Sir Charles Lyell's "Principles" we are largely indebted for most of the facts here recorded.

Hot Springs.

Hot or thermal springs are most abundant in volcanic districts, but are often met with away from the *foci* of disturbance. Their waters are more voluminous and less variable than that of ordinary springs.

Jets of steam, called by the Italians "Stufas," issue at temperatures far above the boiling point near Naples, and in the Lipari Isles, and are disengaged for ages unceasingly.

In old volcanic regions, as central France, the Eifel in Germany, &c., hot springs are frequent. They all give off abundance of gases, and contain earthy matter in solution in great quantities, corresponding in character with those evolved by volcanos.

The hot well of Bath is an illustration of a thermal spring far removed from any existing focus of volcanic energy, being 400 miles from the Eifel, and 440 from the Auvergne. It gives off 250 cubic feet of nitrogen gas daily, a considerable quantity of carbonic acid gas, sulphates of lime and soda, and chlorides of sodium and magnesium. The discharge of water and mineral ingredients is alike uniform and constant from century to century. The temperature remains constant at 120° Fahr.

These Baths were well known to the Romans, and the old Sanatorium of Aquæ Solis is still marked by many Roman remains.

If the solid matter brought up in solution by the Bath waters could be accumulated for one year they would form a square column 9ft. in diameter, and 140ft. in height. Yet all this solid matter is conveyed away in a limpid stream to the Avon, and by the Avon to the sea. (Lyell's "Principles." Vol. i., p. 398.)

What is the cause of thermal springs?—Water descending to deep levels in the strata meets at some point with steam, at a high temperature, which, being converted into water by contact, raises the temperature of the water, which in turn, as the store of heat is accumulated, rises by rents and fissures to the surface in the form of thermal springs.

There seems no doubt that hot springs have a direct connection with volcanos.

1. Hot-springs are present in all volcanic areas.

2. Where not connected directly with volcanos, they are found situated—as in the Pyrenees, the Alps, and the Himalayas—upon lines of dislocation and disturbance where volcanic force—if not visible at the surface—has been in operation far down beneath.

3. Hot springs distant from volcanic disturbances are nevertheless affected by them.

Thus the "Source de la Reine," at the baths of Luchon, in the Pyrenees, was raised suddenly during the great earthquake of Lisbon in 1755, from a tepid spring to 122° Fahr., a heat which it has since retained.

Although springs, as a rule, carry carbonate of lime and sulphate of lime in solution, the hotter thermal springs alone contain large quantities of silica in solution. For example: the hot springs of St. Michael, in the Azores, having a basin 30 feet in diameter, are surrounded by layers of travertin many feet in thickness, deposited on wood, reeds, ferns, &c.

The hot springs of New Zealand are, perhaps, the finest, exceeding even the Great Geyser in Iceland, which also deposits enormous quantities of silica from its waters on cooling, originally held in solution. (Fig. 10.)

Fig. 10.—Section through Basin and Terraces of siliceous sinter. Hot-springs Te Tarata, Rotomahana, New Zealand. (See Hochstetter's New Zealand, p. 137).
a. a. Level of water in repose in great Basin.
b. b. Series of Basins into which the overflow water from the great Basin is discharged during eruptions.
c. Level of the river. *d.* Siliceous sinter and travertin deposited by the evaporation of the water.

The Great Geyser has a cone-like elevation around its basin made up of layers of travertin.

The following are its principal measurements :—

	Feet.
Diameter of basin	56
Depth of tube	74
Diameter of tube	8-10

Professor Bunsen, in 1846, took the temperature of the Great Geyser tube by a thermometer suspended by a string, and found that it was as stated in the annexed woodcut :— (Fig. 11).

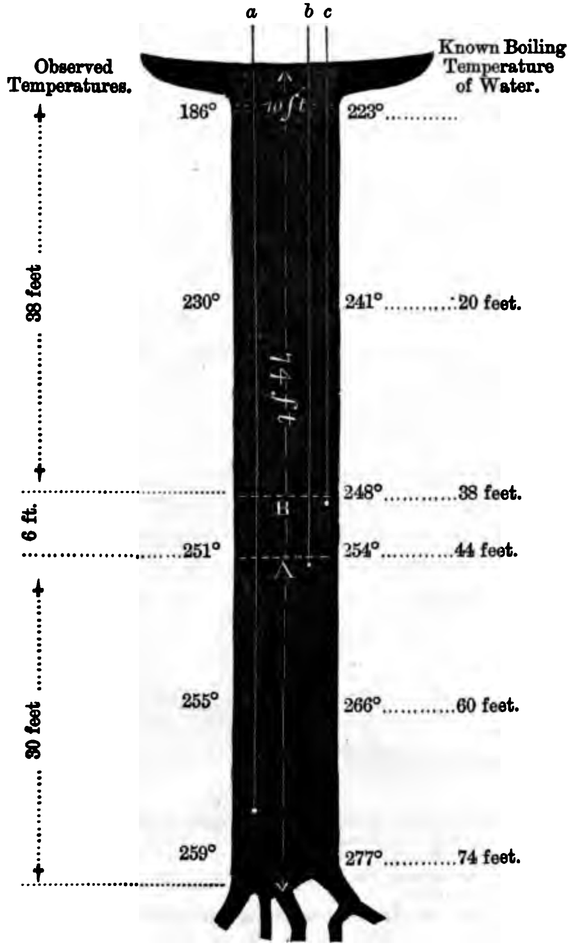

Fig. 11.—Section of Tube of the Great Geyser in Iceland. (After diagram in Prof. Tyndall's "Heat a Mode of Motion," p. 126.)

How does the water rise, under pressure, so much above the ordinary boiling point for water at the surface?—Because, being deprived of air by frequent boiling, it refuses to circulate freely up and down the pipe; therefore, the lower stratum becomes exceedingly heated, and is able at last to overcome the great pressure, and to rise into steam, carrying up with it ten or twelve tons of water with an eruption 100 feet in height.

Professor Bunsen wished to ascertain at what depth steam was formed in the tube of the Geyser. He therefore suspended stones at the ends of cords (*a*, *b*, *c*,) of various lengths, in the tube. When an explosion took place the stone at *c* was found to be blown out, whilst the stones *a*, *b*, remained undisturbed. He thus learnt that it was between A and B that steam was formed; in fact, just at that point in the tube where the observed temperature approaches most nearly the known boiling point for water under the pressure of a column of water of about 40 feet.

Referring the Geyser-action to the crater of a volcano, where steam in a white-hot state under enormous pressure must exist, we can readily see the explanation of the rhythmical explosions which some volcanos constantly keep up.

So long ago as 1825, Mr. Scrope arrived at the conclusion that the mobility of the solid component particles of liquid lava was not due to the mass being in a state of molecular fusion, in which condition it never occurs—subaërially—but to the presence of an interstitial fluid disseminated through the mass, and that this fluid was water in a highly comminuted condition.

This conclusion he seems to have arrived at from observing that the incandescent lava at the moment of its exposure, and in the act of consolidation, always gave off abundance of steam.

"Water," says Mr. Scrope, "we know is converted into vapour only at temperatures increased in proportion to the increased pressure to which it may be subjected; and when altogether hindered from communication with the atmosphere, as in a Papin's digester or other closed vessel, may be made red-hot, without expanding into vapour.

"The moment, however, that the opening is made in the enclosing vessel (reducing the pressure to that of the atmosphere only), it flashes instantly into steam with explosive violence.

"The same effect of course must take place in an imperfect liquid or paste composed of water, and any solid matter in mechanical suspension or mixture, such as flour, clay, sand, or any other granular substance." (Scrope, "Volcanos," p. 39.)

The theories as to the source of volcanic heat are many and various; but the one which may be said to claim the largest share of support is that which attributes the phenomena of volcanos and earthquakes to the reaction of the interior of our planet upon its uppermost strata.

A volcano appears always to keep up a permanent connection between the interior of the earth and the atmosphere, or the sea, either directly or indirectly; sea-water being doubtless the source of many mineral ingredients in volcanic products.

Mr. Hopkins, nearly thirty years ago, and subsequently Archdeacon Pratt and Sir William Thomson, have condemned as untenable and contrary to the known laws of precession and nutation the notion of a globe with a moderately thick crust, and a fluid interior.

In order to produce a complete accordance in the motion of the entire mass, it is necessary, according to these authorities, to assign a solid crust of at least 800 to 1,000 English miles in thickness.

Can any one believe that lava is pressed up through channels of that length?

M. Delaunay has, however, clearly shown that "There is a fundamental error, not in the mathematical formula, but in the condition assumed, namely, that the interior is filled with a free-flowing liquid rock. The interior fluid can only be of the nature of lava, and that, when examined at the surface, however fresh, is a very intractable mass, flowing indeed as does thick honey, pitch, or slag; incapable of moving, at the very utmost, above a few miles an hour, even on a slope of 30°, and on ordinary slopes only one mile, half-a-mile, or even thirty or forty feet in an hour. In this condition it would obey perfectly the motions of the solid crust. The problem solved by Mr. Hopkins, looked at in this light, does really not settle anything as to the thickness of the earth's crust." (Phillips, "Vesuvius," p. 332.)

"The globe is continually, though very slowly, losing heat; it grows cooler in a very small degree, and suffers contraction in the same small degree."

"From what we know certainly of the constitution of the crust of the globe it is of unequal strength to resist change of form in different parts. The weakest part must yield, and if by local yielding the general pressure may be satisfied (which is equivalent to supposing the general pressure determined to a small area), the displacement of small tracts may be extremely great, and the rocks be bent into arches and broken by faults."

"If we are right in our views of the history of the globe, very many epochs would arise, where, first in one region, then in another, lines or areas of relative weakness would be depressed into concave seas, and receive a long series of deposits; and at other times the same areas, or parts of them, might be re-elevated, producing end-pressures and violent local flexures or fractures, resulting in earthquake shocks and volcanic eruptions." (Ibid., p. 335.)

Viewed by the light which volcanic action affords us in other parts of our globe at the present day, the geologist sees the simplest explanation possible by which to understand the upheaval of the sedimentary rocks.

But it is not where volcanic force exhibits itself at the surface, escaping in jets of steam and vapour, or even in lava-flows, that we look for the greatest proof of work accomplished.

As well might we study the smoke-stack of a steam-engine to judge of its horse-power.

No; it is by the consideration of the elevatory force exerted to raise such vast masses as the Himalayas, or the Peruvian Andes, that we can best appreciate the work achieved by upheaval.

Nay more. Not an inch of land could remain permanently above the sea-level but for its silent yet mighty support. And when we look back through Mesozoic to Palaeozoic times we see its active and beneficent agency still in operation—first, in conserving our coal strata by lowering them so as to admit of deposition, to a vast amount, taking place above them; and again in uplifting them so as to bring them, and indeed every other economic stratum of our island within easy access to meet our varied and ever-increasing needs.

VISIT TO THE MUSEUM OF PRACTICAL GEOLOGY.

On Saturday, April 2nd, 1870, a visit was paid to the Museum of Practical Geology, Jermyn Street. The President of the Association and Robert Etheridge, Esq., F.G.S., F.R.S.E., conducted the members present through the Museum, and described the Mineralogical and Palæontological Collections.

VISIT TO THE BRITISH MUSEUM.

A second visit was paid to the British Museum on Tuesday, 12th April, when descriptive lectures were delivered by the President, Henry Woodward, Esq., and Dr. Carter Blake.

Professor Morris described the structure and classification of the Brachiopoda, pointing out generally the range in time of some of the genera. A similar review was given of the Echinodermata, in which the chief subdivisions of the class were separately noticed, especial attention being directed to the distinguishing characters of the free and of the attached echinoderms. The distribution of the genera of these two great groups was also dwelt upon.

Mr. Woodward recapitulated the distinguishing characters of the orders of Cephalopoda, and illustrated his remarks by the specimens around him. The lecturer then described the modifications and structural characters of the genera constituting the families *Nautilidæ* and *Ammonitidæ*.

Dr. Carter Blake gave a general account of the order *Proboscidea*, and pointed out the geographical distribution of *Elephas*, both recent and fossil, as well as the geological position of the fossil remains of this very interesting genus.

EXCURSION TO CATERHAM AND OXTEAD,
April 19th, 1870.

The party proceeded by railway to Caterham, where, on alighting, the members placed themselves under the guidance of Caleb Evans, Esq., F.G.S., who conducted them to the high chalk escarpment overlooking the village of Oxtead.

An explanation having been given of the geological structure of the country then in view to the southward, the party proceeded to examine the various sections exposed on the unfinished line of the Surrey and Sussex Railway, described by Mr. Evans in his paper "On some Sections of Chalk between Croydon and Oxtead," read before the Association on the 7th January.

The members continued the examination of these sections as far as Kenley, and returned to town in the evening from that station.

EXCURSION TO GRAYS, ESSEX, April 23rd, 1870.

The object of this excursion was to examine the extensive chalk quarries in the neighbourhood of Grays, which are worked, not only for the chalk, which is made into "whiting" at this place, but also for the purpose of obtaining flint nodules used in the manufacture of porcelain.

These quarries exhibit a fine exposition of the Upper or White Chalk, and contain the usual fossils of this formation. Of these, specimens of the genus *Cidaris* is found in a fine state of preservation. The excavations here are specially interesting on account of the numerous and deep "sand pipes" filled with Eocene sand and Pliocene gravels, the sides of the "pipes" being lined with chalk flints.

The upper surface of the chalk is slightly eroded and supports a well-marked band of green-coated flints. Above the band of flints, we find the Thanet Sands reposing, and super-imposed on the sands is a bed of Pliocene subangular gravel and sand showing oblique lamination, and this bed may be observed at a little distance in a southerly direction, immediately reposing on the chalk.

The party subsequently visited the mammaliferous deposits, for which this locality is famous, and from which have been obtained remains of *Elephas primigenius*, *E. antiquus*, *Rhinoceros*, *Equus fossilis*, *Bos primigenius*, *Ursus*, *Arvicola agrestis*, *Castor Europæus*, *Felis Catus*, *Felis spelæa*, &c., associated with many species of terrestrial and fluviatile mollusca, still living in the neighbourhood, and three other recent species which are not British. One of these, the *Cyrena fluminalis*, is now living in the Nile. The beds here are extensively worked for brick earth, and are underlain by a stratum of gravel, and overlain by a thick deposit of obliquely laminated sands, showing fine examples of false bedding.

ORDINARY MEETING, MAY 6TH, 1870.

PROFESSOR MORRIS, F.G.S., President, in the Chair.

W. B. Gibbs, Esq., Edward Hill, Esq., and Francis L. Smith, Esq., were elected members of the Association.

The following papers were read: —

1.—"On the Chalk of the Isle of Thanet."
By GEORGE DOWKER, Esq., F.G.S.

(This Paper has been published in a separate form by the Association.)

2.—"On the Geology of the Neighbourhood of Swanage."
By THOMAS D. BOTT, Esq., F.G.S.

(Abstract.)

The strata described in this communication are those occurring in the section along the coast of Dorsetshire, extending from Durlstone Head, at the south-west, to Handfast Point, at the north-east, a distance of about three miles.

Durlstone Head forms the south-western limit to Durlstone Bay, and is composed of Portland Oolite, the beds of which dip at a considerable angle to the north-east, and disappear at a short distance under Purbeck strata. The Portlandian strata are here, as at Portland and Lulworth, capped by the remarkable stratum called the "Dirt Bed."

That this was the soil of a Purbeck forest is evident from the numerous roots of trees with portions of silicified trunks attached and standing vertically, which it contains. Cycadeous plants, locally termed "Bird's nests," characterise this bed, and fir cones, resembling those of the Norfolk Island pine *(Araucaria excelsa)* also occur.

We have in this terrestrial stratum evidence that the Portlandian rock for a lengthened period continued above the waters of the ocean, that after the sun and the rain had disintegrated the surface of the recently formed rock, vegetation ensued, and that after a time Cycadeous plants and lofty coniferous trees afforded a fitting habitat for insects, as well as for their devourers, the Insectivora. Doubtless also the turtle and the crocodile peopled the rivers which watered these forests of the Purbeck land.

The Purbeck strata in this locality are in all about 275 feet thick, and are divided into Upper, Middle, and Lower; respectively, 55, 70, and 150 feet thick.

The Upper Purbecks consist of argillaceous shales, marls, clays, and shelly limestones. These are mostly unfit for building purposes; but there occur in the upper part of the series thin bands of limestone crowded with *Paludina*, and called Purbeck marble, which was largely used in the construction of our cathedrals and other ancient churches. One band contains *Paludina elongata*, and another called "Marble Rag," *Paludina fluviorum* and *Cypris tuberculata.*

The Middle Purbecks are formed by a series of alum shales, marls, and limestones, chiefly of estuarine origin, but partly freshwater. Good building stone is also obtained from this division, at the base of which is the "Cinder Bed."

This remarkable bed is about fourteen feet thick, and contains in abundance *Ostrea distorta*, and some fish, and reptilian remains.

The third division, the Lower Purbecks, is made up of hard and soft marls, and limestones charged with *Cypris Purbeckensis*, and having for its base the "Dirt Bed" before mentioned.

The quarries in the Isle of Purbeck have been worked for fully six or seven hundred years, and have yielded "Purbeck marble" for some of our most celebrated cathedrals.

The following names are locally used to designate the various beds exposed in the quarries:—

Marble rag	Mock hard bed
Single leaper	Pitcher bed
Step bed	Devil's bed
Toad's eye	Thornback
Shiver	Grub
Pitching stone	Pudding
Tomb stone	Shier
White roach	

Peveril Point runs out to sea for a considerable distance, and forms the north-east boundary of Durlstone Bay, which is about a mile and a quarter across from Peveril Point to Durlstone Head.

The picturesque beauties of this bay arrest the attention of the tourist, but the curiously contorted strata of the cliffs will interest the geologist, and will dispose him to speculate upon the causes which here, as at Lulworth and Stare Cove have produced such remarkable flexures.

The town of Swanage is situated in the depression between the high range of the Purbeck hills and the lower range of cliffs of

Hastings Sands, which occupy a considerable part of Swanage bay. The Hastings Sands (the junction of which with the Purbecks is not visible) extend about 3,500 paces, after which Wealden beds are reached.

The Wealden formation is here represented by sands, clays, and calcareous grits, with masses of lignite, and yield reptilian remains, which are often strewn about the shore.

Near the foot of Ballard's Down is Punfield Cove, where, in the space of about 700 paces, we find Wealden, Neocomian, Gault, and Upper Greensand strata. As the vegetation is here abundant, it is difficult to determine accurately the extent of each series of beds; but, roughly, the Wealden may be about 50 paces, the Neocomian 250, the Gault 200, and the Upper Greensand 250. The Gault does not appear to be fossiliferous in this place, but the Upper Greensand yields characteristic species.

The passage from the Upper Greensand to the Upper Chalk is well seen; the Firestone or Chloritic Marl, the Chalk Marl, and the Lower Chalk all being exposed.

The Lower Chalk forms Ballard's Down, which terminates in a bold cliff 350 feet high. Beyond this point a depression marks the commencement of the Upper Chalk, which forms the northern extremity of Swanage Bay, called Handfast Point.

The chalk is here nearly vertical, as shown by the bands of flints, and the section exposed is altogether very similar to the well-known one at Scratchell's Bay, near the Needles. Here, too, are detached pinnacles of chalk standing well out, and rendering still stronger the resemblance between the two places.

How great must have been those mighty forces which produced the upheavals of which the evidences are here so abundantly found! As there is no trace of an eruptive rock in the district, it would seem probable that one great seismic movement, beginning at Whitecliff Bay, passing through the whole of the Isle of Wight to the Needles, extending to Handfast Point, and on through the Isle of Purbeck to Whitenore Bay, effected the change, and produced the phenomena, which in this beautiful locality now excite the admiration and the wonder of the visitor.

EXCURSION TO LEWISHAM, MAY 7TH, 1870.

The beds exposed at the brick-pits at Lewisham exhibit the white chalk with its cover of green-coated flints, overlaid by the ash-coloured Thanet Sands of marine origin, and these succeeded by beds of rolled pebbles and clay, over which occur the fluvio-marine strata of the Woolwich series, consisting of beds of *Cyrena*, *Melania*, &c., with an intercalated bed of oysters; over these are clays with leaves, lignite and carbonaceous layers, with fragments of wood pierced by the *Teredo*, and much iron pyrites and selenite. Above these fluviatile strata is a bed of pebbles, at the base of the marine deposit of the London Clay with its characteristic *Septaria*. The surface features of the district were also noticed as due to the nature of the strata, the faultings, and subsequent denudation they have undergone.

EXCURSION TO STROUD, MAY HILL, AND SWINDON, MAY 9TH, 10TH, AND 11TH, 1870.

The party proceeded to Stroud by the Great Western Railway, and, accompanied by the President, Professor Morris, examined sections of the successive formations from the Lower Lias to the Great Oolite, of which the vales and hills of this beautiful district are formed. The Inferior Oolite is here very fossiliferous, and good specimens of *Terebratula fimbria*, *Terebratula globata*, *Rhynchonella spinosa*, *Gryphæa Buckmanii*, *Pholadomya fidicula*, and *Trigonia costata* were procured.

The physical features of the district were ably explained by Professor Morris, who subsequently pointed out a bed of gravel containing remains of *Elephas primigenius*.

On the following day, the party proceeded to Longhope, on the west of the Severn valley, where Upper Silurian strata are well exposed. A good section of Ludlow rocks is seen in a quarry opposite the railway station, and here the characteristic fossils of this formation are met with, the most abundant species of which is, at this place, *Chonetes striatella*. The remarkable hill, May Hill, was then ascended. This ascent takes the observer over Ludlow, Wenlock, and Upper Llandovery strata,

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the last named being the May Hill sandstone and grits, at one time thought to be of Caradoc age.

Many Brachiopods, including *Atrypa reticularis*, *Meristella tumida*, and *Strophomena depressa*, as well as several corals, such as *Halysites catenulatus*, *Favosites Gothlandica*, *Cyathophyllum*, and *Omphyma* were found in the quarries on the side of the hill. Remains of the trilobites, *Calymene Blumenbachii* and *Phacops caudata* were also obtained.

The view from the summit of May Hill, 965 feet above the level of the sea, is very extensive, and, to the geologist, unusually interesting; for here the observer stands on a Silurian island of the old Mesozoic sea, and looks from this Upper Llandovery elevation over Wenlock and Ludlow rocks, over the Old Red Sandstone country of Herefordshire, and the coal fields of the Forest of Dean; over Triassic rocks, and over the wide Liassic vale of Severn away to the Oolitic escarpment of the Cotteswold hills.

The third day was occupied by visits to Swindon, in Wiltshire, and Farringdon, in Berkshire.

The extensive quarries in the Portland Oolite at Swindon are widely known, very fine building stone being sent from these quarries in large quantities to distant places. Some of the characteristic fossils of Portlandian strata are abundant here, especially *Trigonia gibbosa*, *Cardium dissimile*, and *Cerithium Portlandicum*. The upper beds are covered conformably by Purbeck strata, some of which are charged with *Cyprides*. Above these deposits a patch of Lower Greensand may be noticed, and Kimmeridge Clay will be found in the lower levels near the railway station.

Near Farringdon the celebrated "Sponge Gravel" is exposed in pits, at the village of Little Coxwell. Here the fossil sponges are very abundant, as are also Brachiopods, and some fossils derived from the underlying Coral Rag were observed.

EXCURSION TO CRAYFORD, MAY 21ST, 1870.

The party, on arriving at Bexley station, proceeded to Crayford, and visited the extensive excavations in the brick earth, gravel, and chalk at this place.

The strata here are analogous to those at Grays, on the north side of the Thames valley, described in the notice of the excursion to that place, on the 23rd of April last, and the sections at the two places are consequently similar. In one part of the pit the chalk is seen covered with the Thanet Sands, these again being covered with beds of ferruginous gravel. In another portion of the excavation the successive accumulations of the ancient valley deposits are well seen. These deposits consist of beds of gravel, sand, loam, and clay, which indicate fluviatile origin, inasmuch as some of the layers contain many recent species of land and fresh-water mollusca. With these are found mammalian remains, similar to those recorded at p. 29, as occurring at Grays.

EXCURSION TO TILBURSTOW AND NUTFIELD, MAY 28TH, 1870.

On arriving at Caterham, the party, under the guidance of C. J. A. Meyer, Esq., F.G.S., proceeded along the Lewes road to Tilburstow Hill, examining on the way the successive outcrops of the Lower Chalk, Upper Greensand, Gault, and upper and middle beds of the Lower Greensand. At Tilburstow Hill, the strata of which were pointed out by Mr. Meyer as belonging to the middle and lower beds of the Lower Greensand, the members were interested in observing the "fault" long ago described by Mantell. It is now much obscured by *débris* and vegetation.

The party then proceeded along the outcrop of the Lower Greensand through Bletchingley and Nutfield towards Redhill, examining the various quarries which are being worked for the purpose of obtaining fuller's earth; which, in this district, though underlying a comparatively small area, is found to be of very superior quality, and consequently gives great value to the land under which it occurs. This bed of fuller's earth is in the Lower Greensand, the formation which is known by the name "Fuller's Earth," is much lower in the stratigraphical scale, being of Lower Oolitic age, and lying between the Inferior and Great Oolites. Very fine crystals of Barytes occur in the fuller's earth at Nutfield, and some of these have small cubic crystals of Iron Pyrites attached, and, not unfrequently, fine crystals of quartz.

Another valuable product of the Lower Greensand of this neighbourhood is the well-known building stone "Kentish Rag," which is largely quarried here, some fine sections of this part of the Lower Greensand being exposed near Bletchingley. The Lower Greensand of Nutfield also furnishes road material, a thick bed of "Chert," much used for "road metal," occurring at this locality.

EXCURSION TO AYLESBURY, June 1st, 1870.

The strata of the district near Aylesbury consist chiefly of Upper Oolitic formations; the lowest visible being the Kimmeridge Clay, which is worked for making bricks near Hartwell, and contains many fossils, as *Ammonites biplex*, *Belemnites*, *Cardium*, *Astarte*, &c., as well as remains of Pliosaurus; overlying the clay is a bed with pebbles, marked by the outburst of springs, and forming the commencement of the Portland series, followed by beds of sand and stone, underlying the stronger bands of Portland limestone (extensively worked at Hartwell), and replete with the usual fossils, as *Ammonites giganteus*, *Cardium dissimile*, *Ostrea falcata*, *Trigonia gibbosa*, &c. Over these a change of conditions is observed by the incoming of the estuarine Purbeck strata, consisting of shales, clays, and marly limestones (pendle), with *Mytilus*, *Cyrena*, many *Cyprides*, fish, and remains of insects and plants. The junction of the overlying beds is not always to be observed; but there is evidence, if not at present, at least of the former existence of the Wealden beds by the presence of the plant *Endogenites erosa*, and of *Cyrena*, *Unio*, and *Paludina*. Evidence of denudation is apparent prior to the deposition of the Lower Greensand strata, which caps the hill tops at Hartwell and Stone, and contains some of its characteristic fossils, as *Exogyra sinuata*, *Pecten obliquus*, *Ostrea macroptera*, &c. Between Stone and the Chiltern Hills, the overlying cretaceous beds, Gault and Upper Greensand may be traced. The immediate district is free from much superficial deposit: there is, however, a bed of gravel and clay containing shells and mammalian (elephant) remains on the side of the clay-pit previously mentioned. The physical features of the country around are due to subsequent denudation; and thus the outliers of Portland and Purbeck strata, upon which stand Aylesbury, Hartwell, Stone, Brill, and other towns, are merely portions of these beds, once continuous, and which, as is well known, may be traced for some distance to the south-west, although in the opposite direction they are not much further to be observed.

ORDINARY MEETING, 3RD JUNE, 1870.

PROFESSOR MORRIS, F.G.S., President, in the Chair.

The following paper was read:—

"ON A VISIT TO THE SCILLY ISLES."

By C. T. RICHARDSON, Esq., M.D., Vice-President.

(Abstract.)

In the early portion of the paper the author pointed out the remarkable facilities which now existed for becoming practically acquainted with the general features of the geology of the western districts of Devon and of the whole promontory of Cornwall, due to the high level at which it was necessary to construct the West Cornwall Railway, in order to cross the valley at Ivy Bridge, and the sinuous bay at Saltash. By travelling over this railway a very accurate general idea of the characters of the whole district may be obtained, even during the hurried passage of the train on its route to Penzance. Running as it does through some of the principal districts, furnishing both tin and copper, many of the facts connected therewith may be readily gathered, and some idea formed of the extent of area over which these minerals are developed, and also of the districts where the occurrence and preparation are to be seen of the interesting material known as *Kaolin*, or China clay, the essential element in the manufacture of our improved porcelains or keramic ware.

The author described successively in detail the several prominent features of the district—the serrated and sinuous coasts on both shores, with their lofty and precipitous rocky cliffs; the general high table-land of the peninsula denuded and eroded into deep and numerous valleys, constituting the well-known hilly character of the country; the great divisions and different nature of the rocks forming the greater portion of the district; the granitic, and the schistose, and the different features each gives to the aspect of the country; the isolated developments of granite at Dartmoor, Templemoor, Redruth, St. Austell's, St. Michael's Mount, the Land's End, and Scilly Isles, with all the rocky fragments fringing the coasts at greater and less distances, as at the Longslips, the Wolf Rocks, and the Eddystone.

The conclusions sought to be conveyed by the author were, that Cornwall, as at present existing, was but the remnant of a former great and vast area extending seawards to the south and west, continuous with Scilly and the more distant similar rocks on the coast of Brittany; that this continuity was interrupted by some correspondingly extensive and powerful cause, operating, in all probability, as may be gathered from a consideration of the history of Dartmoor, at or about the period of the close of the Carboniferous era; that the Scilly Isles formed a part of the line of fracture, and were the advanced headland of Cornwall, as does the Land's End now form the extremity of a similar coast line traceable through the Wolf Rocks to the Eddystone, and still further eastwards.

In conclusion, the author impressed with earnestness the necessity for students of Geology, at the outset of their studies, visiting such scenes as the Land's End, in order, as early as possible, to acquaint themselves with the visible operations of nature on a large scale, so as to be able to form a somewhat proximate idea of the extent of area over which her influences are exerted, and the power and might with which her never-ending forces are felt. The Scilly Isles, too, are well worthy the attention of all Natural History students, since they possess great interest to observers of Nature generally, and there are now great facilities of access from Penzance.

Specimens of several of the varieties of granite from St. Mary's, Scilly, and the neighbourhood of the Land's End, presenting many of the well-known characteristic variations of chemical and mineral composition, were exhibited, and elicited very instructive demonstrations; as did also a quantity of sand from Porthcurno Bay. This material forms the artificial soil from which is raised the enormous quantity of early cauliflowers and potatoes sent to our London markets, it being composed principally of the felthspathic materials of the granite and the comminute remains of marine shells.

EXCURSION TO HERNE BAY, 6th June, 1870.

Director—The President, Professor Morris, F.G.S.

On arriving at Herne Bay, the party proceeded eastwards along the shore, and examined the Lower Eocene strata, which are so well exposed in the fine coast section between Herne Bay and the Reculvers.

These strata consist, in ascending order, of the following groups:

1st, Thanet Sands.

2nd, the lowermost beds of the Woolwich Series.

3rd, the "Oldhaven Beds."

4th, the lower beds of the London Clay.

Of these the "Oldhaven Beds" are perhaps the most interesting, since here is seen the typical section, Oldhaven Gap, from which the beds are named, being situated little more than a mile east of the Reculvers.

The "Oldhaven Beds" were so named by Mr. Whitaker, and from his paper "On the Lower London Tertiaries," in the Quarterly Journal of the Geological Society, Vol. xxii., p. 404, the following list of organic remains has been obtained:—

List of Fossils in the Oldhaven Beds of Central and East Kent.

FORAMINIFERA.
Cristellaria calcar. *Linn.*
(var. platypleura. *Jones.*)
ACTINOZOA.
sp. (small coral).
ECHINODERMATA.
Diadema ? sp.
Ophiura Wetherelli. *Forbes.*
Spines of Echini.
CRUSTACEA.
Balanus Chisletianus. *G. B. Sow.*
LAMELLIBRANCHIATA.
Astarte Burtini. *Lajonk.*
——— elevata. *G. B. Sow.*
——— gracilis. *Goldf.* (var. multilineata. *Wood*).
——— sp.
Cardium Laytoni. *Mor.*
——— nitens. *Sow.*
——— Plumsteadiense. *Sow.*
Corbula Henckliniana. *Nyst.*
——— Regulbiensis. *Mor.*
Cyprina Morrisi. *Sow.*
Cyrena cordata. *Mor.*
——— cuneiformis. Fér.
?——— deperdita. *Sow.*
——— obovata ? *Sow.*
——— tellinella. *Fér.*
Cytherea obliqua. *Desh.*
——— orbicularis. *Edw.*
——— ovalis. *Sow.* (var. ?)
Glycimeris Rutupiensis. *Mor.*
——— sp. or Panopæa. sp.
Limopsis aurita. *Brocchi.*
? Lucina sp.
Mactra. sp.
Modiola. sp.
Nucula margaritacea. *Lam.*
——— nuclea. *Linn.*
——— striatella. *Wood.*
——— tenuis. *Montagu.*
——— sp.
Ostrea Bellovacina. *Lam.*
——— tenera. *Sow.*
——— sp.
Panopæa intermedia. *Sow.*
Pectunculus brevirostris. *Sow.*
——— Plumsteadiensis. *Sow.*
——— terebratularis. *Lam.*
GASTEROPODA.
Aporrhais Sowerbyi. *Mant.*
Buccinum concinnum. *G. B. Sow.*
? Bulla concinna. *Wood.*
——— utricula. *Nyst.*
Calyptræa trochiformis. *Lam.*
Cerithium funatum. *Mant.*
Chemnitzia elegantissima. *Mont.*
Clavatula brachystoma. *Phil.* ?
? Dentalium nitens. *Sow.*
Fusus complanatus. *Sow.*
?——— latus. *Sow.*
——— subnodosus. *Mor.*
——— tuberosus. *Sow.*
——— sp.
Helix. sp. ? !
Limax. sp. ? !
Melania inquinata. *Defr.*
Metula juncea. *Sow.*
Natica catenoides. *Wood.*
——— Hantoniensis. *Linn* ?
——— labellata. *Lam.*
——— subdepressa. *Mor.*
Odostomia. sp.
Pleurotoma acuminata. *Sow.*
——— comma. *Sow.*
——— sp.
Pyrula nodulifera. *G. B. Sow.*
——— sp.
Ringicula. sp.
Rostellaria. sp.
Scalaria. sp.
PISCES.
Lamna elegans. *Ag.* ?
sp. ?
Otolithes.
Fish remains.
REPTILIA.
Chelonia (Bones).
——— (Fragments of carapace).

Many of the species in the above list were obtained from Grove Ferry, a few miles inland, where an exposure of the Oldhaven Beds occurs. From Grove Ferry these beds continue along the Valley of the Stour westwards, for a considerable distance. But about five miles west of Canterbury their outcrop takes a northerly direction, and extends to the marshes south of Whitstable Bay. Outliers are also found to the west of the mouth of the Swale; and in the Western Division of Kent a sandy pebble bed, seen at Blackheath, Abbey, Wood, Shottenden Hill, and Sundridge, is considered the equivalent of the Oldhaven Beds. At Oldhaven Gap, however, the beds consist chiefly of "a fine light-buff sand," from 15 to 20 feet thick, under which lies a sandy pebble bed, about two feet in thickness.

EXCURSION TO HAMPSTEAD, 11TH JUNE, 1870.

Directors—The President, S. R. PATTISON, Esq., F.G.S., and CALEB EVANS, Esq., F.G.S.

The party met at the Swiss Cottage Station, and proceeded to Hampstead across the Conduit Fields. The position of the Midland Railway tunnel, excavated through stiff London Clay, containing *Nautilus*, *Pholadomya*, *Corbula*, and other genera was pointed out; and Professor Morris explained the geological structure of the extensive district seen to the south and south-west, including the Chalk range of the North Downs and the Tertiary hills of Norwood and Richmond. The sections of the Middle Eocene, or Bagshot Sands, by the side of a new road near the Sailors' Orphan School, were then examined, and the position of these sands, forming a capping of the hill, and resting on the London Clay, was explained by Mr. Pattison. The age of a pebbly bed, resting on an irregular surface of the sands, gave rise to some discussion. It was observed that many of the pebbles had their longer axes in a nearly vertical position. After a brief visit made to the tomb of Mr. Daniel Sharpe, a late distinguished president of the Geological Society, the party walked through Frognel and across the Heath to the "Leg of Mutton Pond," at North End. Here patches of the London Clay, which had been raised to the surface from some drainage works, were seen, and specimens of *Pectunculus decussatus*—a fossil characteristic of the "Highgate Zone" of the London Clay—were obtained. From an adjacent hill, capped by the Bagshot Sands, Professor Morris pointed out

Harrow Hill, also capped with sand, and explained that this upper deposit must once have been continuous, and that the intervening valley had been formed by denudation; he also explained that the sand at the top of the hill was a water-bearing stratum, giving rise to several streams at the junction with the subjacent clay, and that the numerous minor valleys descending from the hill had been formed by the streams. Good examples of these valleys were seen at North End and at the Vale of Health, the pond at the latter spot forming the headwaters of one of the branches of the Fleet. The sands were also examined in the large pit on the top of the Heath. After a visit to the Chalybeate Spring, in Well Walk, the party concluded a very pleasant excursion by proceeding to the residence of Mr. Caleb Evans, at Downshire Hill, and inspecting the fine collection of London Clay fossils which that gentleman possesses.

EXCURSION TO FOLKESTONE, 18TH JUNE, 1870.

Director—The President, PROFESSOR MORRIS, F.G.S.

This excursion, was, in its results, perhaps one of the most successful of the session.

The beauty of the weather, enhanced by the delicious coolness of the sea-breezes; the fine state of the sections visited; and the abundance of the fossils, left nothing to be desired by those whose good fortune had again placed them under the guidance of Professor Morris.

On arriving at the pier, a rapid survey was taken of the chief points of interest along the coast to right and left of Folkestone. The fine chalk cliffs forming the northern boundary of Eastware Bay, rising at Folkestone Hill to a height of 566ft.; the outcrop of the soft clay beds of the Gault, and the consequent sudden depression and recedence of the coast line; the rise of the sands and stone-beds of the Neocomian strata from beneath Copt Point, and their continuance to and beyond the town of Folkestone, were all matters of remark; while the former existence and position of a gravel-bed containing the remains of extinct mammalia—*Elephas*, *Rhinoceros*, &c.—on the high ground above the harbour, was noted.

The strata first examined in detail were some dark-greenish subargillaceous sands, known as the "Sandgate Beds," which rise on the shore at a short distance west of Folkestone. The low undercliff which skirts the shore from Folkestone nearly to Hythe, was shown to owe its origin to the presence of these beds, which, from their retention of water and slight coherency of structure, have caused the frequent subsidence of the beds above. These greenish beds it was observed contain sulphur, iron pyrites in minute grains, and a large proportion of silicate of iron. Unlike the sands above, they do not effervesce in acid.

The sands and siliceous sandstones of the "Folkestone Beds" above were next examined, and proved to be highly interesting. Sandy conglomerates, containing rounded fragments of quartz, white or grey, often stained to a greenish colour; fragments of quartzite, jasper, and flinty slate, mingled with small phosphatic nodules and casts of shells, were seen to alternate with soft marly beds, containing an abundance of fossils. The stone beds at a higher level, ranging upwards almost to the Gault, were shown by Professor Morris to consist, in great measure, of the remains of sponges. This was best seen beneath the cliffs to the east of Folkestone; the huge slabs of stone just above tide-mark being in many places literally made up of sponges, exhibiting in the weathered cavities left by the decomposition of the more ramose varieties a perfect network of siliceous spiculæ. Sections showing the passage of the Neocomian sands into the Gault were next examined, the chief points observed being the gradual increase of argillaceous matter in the sands in approaching the Gault; the occurrence of a band of phosphatic nodules, associated with *Ammonites mammillaris*, at about three feet beneath the Gault; and the abundance of pyritized coniferous wood contained in the nodular phosphatic bed at the base of the Gault itself. Evidence of the constant slipping forward of the Gault over its own basement bed was in places very apparent.

As the tide fell, the brilliantly-coloured fossils of the Gault became exposed to view upon the flat shore of the Bay, and many beautifully preserved specimens were carried off. After a few words from Professor Morris on the great influence of the geological structure of a country upon its physical features, so clearly seen in the country around Folkestone, a rough walk over the broken undercliff of the Gault, towards the station, terminated the day's proceedings.

EXCURSION TO WATFORD, June 23rd, 1870.

Director—John Hopkinson, Esq., F.G.S.

(Report by Mr. Hopkinson.)

On alighting at Bushey Station the party examined the Chalk-pit close to the railway. A good section of the Upper Chalk, on which Watford is situated, is here seen, and overlying it, a pebble bed of the Woolwich and Reading Series has recently been exposed. This bed completely thins out in the pit, and is succeeded by clay-drift and sandy gravel (terrace gravel), which repose, in other parts of the pit, immediately on the chalk. The Chalk Hill Pit, which furnished instructive examples of "pipes," was next noticed, and then the party proceeded to Watford Heath Kiln, where they were joined by Mr. W. T. Stone, who showed the sections then exposed, and explained how they varied in parts of the pit not now worked. Professor Morris had previously explained the general features of the country, especially with reference to the form of the ground and general contour of the hills, as caused by denudation acting on what were originally weak lines of resistance.

The London Clay, with its basement bed, and between it and the Chalk a series of beds of sand and clay (with associated pebble beds), which were considered the equivalents of the Woolwich and Reading Series, and possibly in part also of the Thanet Sands, are here seen.

The following section is slightly altered from one given by Mr. Whitaker, in the "Memoirs of the Geological Survey" (No. 7):—

			ft.	in.
London Clay.		*a.* Brown clay, with selenite (no fossils)	9	0
	Basement Bed.	*b.* Brown sandy clay with selenite, numerous fossils, and at the bottom a layer of shells.	5	0
		c. Flint pebbles, with shark's teeth (*Lamna* and *Otodus*)	0	3
		d. "Brown sandy clay, more sandy than the upper bed, with iron sandstone, and a little ironstone at the base. At the top here and there, a bed of soft clayey sandstone, bored by *Lithodomi*, from 6 inches to a foot thick."	7	0
		e. Flint pebbles with oyster shells (*Ostrea Bellovacina*, Lam.)	0	3
Reading Beds.		*f.* Grey and mottled clay, with a few small pebbles	3	6
		g. Light coloured sand	16	0
		h. Sand, with beds of pebbles	9	0
		i. Mixture of sand and clay, light coloured	3	0
		Not shown—to the chalk	6	0

The shells at the bottom of the bed marked *b* are mostly in fragments, but several perfect specimens of the following, amongst other species, were collected:—*Aporrhais Sowerbyi*, Mant., *Cyprina Morrisii*, Sow., *Cyrena cuneiformis*, Fér., *Cytherea obliqua*, Desh., *Natica labellata*, Lam., *Nucula* sp. (? *margaritacea*, Desh.), and *Panopæa intermedia*, Sow. But the best collection of fossils was made from some tabular masses, or concretions of calcareo-argillaceous sandstone occurring at intervals in this bed, but not seen *in situ*, the section from which they were obtained not having been worked for some time. In *d*, Mr. Stone has found several rare fossils, amongst which some turtle bones and a mammal's tooth (*Hyracotherium leporinum*, Owen*) were particularly noticed. Below *e* no fossils have been found.

On leaving this interesting pit, the party proceeded to Bushey Kiln, where a section, somewhat similar, but with an additional bed of clay with "race," and showing in the lower portion alternating beds of sand and pebbles, is exposed.

After a delightful country walk, Berry Wood, near Aldenham, was reached. Here the Chalk is covered by thick beds of flint and pebble gravel, and by the roadside some Silurian and other boulders, one deeply scratched, attested the proximity of the Boulder Clay, which, in Bricket Wood, about three miles to the north, is from 20 to 30 feet thick. In Berry Wood is a chalk pit abounding in the remains of sponges, surrounded by mere shells of flint, and containing "spicules," Foraminifera, and even Polyzoa, beautifully preserved. Once in this pit it was difficult to leave, every "find" seeming better than the last; every sponge or ventriculite more perfect in structure. But the sun had set, and the approaching darkness warned that this attractive spot must at last be left. By a short cut across the fields, Watford Station was soon reached, and the party returned to London after a most successful and enjoyable excursion.

* This specimen has been kindly examined and identified by Professor Owen.

ORDINARY MEETING, July 1st, 1870.

Professor Tennant, F.G.S., F.C.S., &c., Vice-President, in the Chair.

W. D. Campbell, Esq., and Thomas H. Blakesley, Esq., were elected members of the Association.

The following papers were read:—

1.—"Two Days in a Mining District."

By J. Logan Lobley, Esq., F.G.S.

Having received an invitation from a gentleman possessing an extensive acquaintance with mines and mining to visit with him the Copper and Tin Mining District of East Cornwall, I gladly availed myself of my friend's offer to show me a little visited, though highly important district, and to give me a glimpse of the underground life of a not inconsiderable section of our industrial population.

Whether the traveller be a geologist or an artist, a lover of Nature or merely an admirer of beautiful scenes, few railway journeys in England will afford him more pleasure than that between Exeter and Plymouth. "The land of deep valleys" is also a land with a beautiful coast; and both these features of Devonshire are seen to great advantage as he proceeds westward along the South Devon Railway.

From Devonport steamers run up the River Tamar to Calstock, a small town on the Cornish side of the river, where the ore obtained from the many neighbouring mines is shipped. This little Cornish town is, accordingly, the port of the district about to be described, and a convenient resting place for a visitor to the mines, though the town of Callington is the mining capital of the district.

Here I am tempted to say a few words about "the three towns" —Plymouth, Stonehouse, and Devonport—for their characteristics and surroundings are, in many respects, remarkable; but as they are not in our mining district, I must pass on. It would, however, be unpardonable were I to pass over without notice the beautiful scenery of the River Tamar; for the glassy smoothness of the water, reflecting the sunlight of a lovely afternoon, the dark masses of the woods which richly clothe the boldly swelling hills on either side, as well as the variety of views consequent upon the numerous windings of the river, have left a very vivid impression of exquisitely soft and beautiful river scenery. The great sleepy looking hulls of the men-o'-war lying up in ordinary on the broad bosom of Hamoaze, the remarkable bridge at Saltash, "the meeting of the waters" of the Tamar and the Tavy, and the beautiful domain of Pentilly, are successively passed; and we see in the distance the summit of Kit Hill in Cornwall, and the Tors of Dartmoor in Devonshire. These hills are granitic, and it is near and in the granite that the most important metalliferous veins or lodes occur; but engine-houses perched on eminences are a further indication to us of our approach to a mining district, and in a little time the numerous buildings of the Devon Great Consols Mine, perhaps the largest copper mine in the world, are seen on a noble hill which closes up the view to the north. One of the mines passed is abandoned, in consequence of the river some years since having broken into the workings, which extended beneath its bed.

We left the steamer at Clothele, a landing place some little distance below Calstock, in order to examine some strata near, as well as to enjoy the beautiful walk through the woods which lie between that place and Calstock. This romantic road passes the front of Clothele House, a seat of the Earl of Mount-Edgecumbe, and one of the most charmingly picturesque mansions of the Tudor period that can well be imagined. All the surroundings, too, are in keeping, and no modern "improvements" detract from the quaint and antique character of this fine old place, but there it stands as it did 300 years ago, with its many gables, its porches, its oriel windows, its terraces, its antique gardens and clipped yew hedges, and its old orchards mingling with the thick woods around, a very type of the home of the fine old English gentleman of the days that are gone. We descended by a winding path, and crossed a deep valley called Danes Comb, from having been used as a place of embarkation by the old sea kings when they held much of the interior. The inhabitants of the district, even of the present day, have a tradition that pots of gold and silver lie buried in this valley, left after the precipitous flight of the Danes to their ships when they suffered their last defeat. It was now dusk, and we hastened to Calstock, where we were to take up our quarters for the night, and where two superintendents of neighbouring mines awaited our arrival.

On the following morning a pleasant walk along the river bank of half a mile brought us to the Okel Tor Copper Mine, an exceed ingly good mine to visit, since it is one of average size, and in full working order. This mine is, moreover, very well planned and arranged, and the aboveground works are compact and in good condition. As we intended to spend the day in visiting various mines, and in making ourselves acquainted with their distribution, as well as with the prominent features of the district, the descent into the mine, which occupies much time, was postponed until the following day. The process of dressing the ore was, however, going on briskly; there was, therefore, sufficient to interest us aboveground.

The material brought to the surface, the result of the mining operations underground, is not, as some might suppose, altogether copper ore, but a mixture of the ore, or bi-sulphuret of copper, with mundic, quartz, fluor-spar, and various earthy matters. It becomes, therefore, requisite to separate the ore from these other substances, and so minimise the bulk before shipment, the smelting or reduction of the ore to metallic or commercial copper not being carried on here. This preliminary process is called "dressing," and employs a considerable number of people about the mouth of the mine. The excavated material on being brought up is a yellowish grey aggregation of stones of all sizes and coarse mud, and it is in the first place necessary that the whole should be brought to the condition of coarse powder. The stones are first separated from the rest of the mass by means of a screen, and after being washed they are looked over, and the worthless ones, or those without ore, quickly detected by the practised eyes of the workpeople, rejected; while those containing ore are passed on to other workers, who, with peculiar shaped hammers, break them into smaller pieces, and the non-metalliferous portions are cast aside. By these operations a large quantity of worthless material is got rid of, and the stones are reduced to the size of apples and walnuts. These stones are now taken to the crushing-mill, where they are reduced to a coarse powder; this is now added to the small stuff which passed through the screen, and the whole is taken to the jigging machinery. The "jigging" is a very peculiar process, and has the effect of separating the ore from the small pieces of quartz and other substances with which it is yet intermingled. An oblong trough, about 4ft. long, 18in. broad, and 1ft. deep, fitted with a perforated bottom, is suspended by a rod of iron from one end of a long lever, and lies in another and larger trough, through which a stream of water is constantly running. The first-mentioned trough is almost filled with the crushed material, and then quickly shaken or "jigged" by means of the lever, while the stream of water is passing through the trough and mingling with its contents. In a little time it will be found that the ore, in consequence of its superior specific gravity, is at the bottom of the trough, while clean quartz, mundic, and fluor-spar form a distinct layer above, and the earthy or clayey matter has all passed away with the water. The upper or worthless portion of the contents of the trough is removed by means of an iron scraper, and the ore, thus freed from all extraneous matter, is then dried. This completes the dressing, and the ore is now ready for shipment to Swansea and other places to be smelted.

The per-centage of metallic copper which the "dressed" Cornish ores yield varies slightly from year to year, as will be seen from the following table, giving the produce of these ores for each year from 1857 to 1869 :*—

THE AVERAGE PRODUCE OF THE CORNISH COPPER ORES FOR EACH YEAR SINCE 1857.

Year.	Average produce.	Year.	Average produce.
1857 -	- $6\frac{1}{2}$ per cent.	1864 -	- $6\frac{1}{4}$ per cent.
1858 -	- $6\frac{3}{8}$ "	1865 -	- $6\frac{1}{8}$ "
1859 -	- $6\frac{3}{8}$ "	1866 -	- $6\frac{1}{8}$ "
1860 -	- $6\frac{1}{2}$ "	1867 -	$6\frac{5}{8}$ "
1861 -	- $6\frac{1}{2}$ "	1868 -	- $6\frac{5}{8}$ "
1862 -	- $6\frac{1}{4}$ "	1869 -	- 7 "
1863 -	- $6\frac{3}{8}$ "		

A large quantity of iron pyrites or "mundic" is associated with the copper ore, the latter being a bi-sulphuret of copper, while the iron pyrites is a bi-sulphuret of iron. This mundic is not, however, valueless, as it is sold sometimes for upwards of £1 per ton; the total amount from the Cornish mines for 1869 being 3,258 tons 11 cwt. 2 qrs., of the value of £2664 13s. 10d. It is used, not as an iron, but as a sulphur ore, and very extensive mines in Spain are worked exclusively, and most profitably for this mineral.

Arsenical iron pyrites is another substance found with the copper ores of Cornwall, and a source of profit to the miner. From the arsenical pyrites produced by the mines of Cornwall, in 1869, 1189 tons 1 cwt. 2 qrs. of "crude arsenic" was obtained. This sold for £3737 18s. 10d.

* The statistical and topographical details in this paper are given on the authority of the "Mineral Statistics of the United Kingdom," the "Cornwall and Devon Mining Directory," and Sir Henry De La Beche's "Report on the Geology of Cornwall, Devon, and West Somerset."

Blende, or, as the miners call it, "black jack," also accompanies these ores, and is largely used as an ore of zinc, of which metal blende is a sulphuret.

The total amount of copper ore obtained in Cornwall, with the produce of metallic copper for ten years, is given in the Table below. In this Table will also be found the number of copper mines worked in each year. This number, it will be seen, has undergone great diminution during the last few years, and was less in 1869 than in any of the nine preceding years. From a return for the year 1838, however, it is found that the number of Cornish copper mines worked in that year was 76, being eight less than the number in 1869 :—

TABLE SHOWING THE AMOUNT OF COPPER ORE AND METALLIC COPPER DERIVED FROM THE MINES OF CORNWALL FOR EACH OF THE TEN YEARS ENDING 1869, WITH THE NUMBER OF COPPER MINES WORKED IN EACH YEAR.

Year.	No. of Mines	Copper Ore.	Copper.
		Tons.	Tons.
1860	95	145,359	9,649
1861	97	143,119	9,306
1862	177	141,800	9,063
1863	166	129,229	8,411
1864	173	127,633	7,963
1865	148	121,253	7,413
1866	130	103,670	6,551
1867	109	88,603	5,990
1868	100	86,722	5,725
1869	84	71,790	5,144

After leaving the Okel Tor Mine, we traversed a road along the side of the valley gradually rising to higher ground, and passing the seat of the Trelawny, the hero of the old Cornish song—

"And shall Trelawny die?
And shall Trelawny die?
Then twenty thousand Cornish men
Will know the reason why."

Still ascending, we reached the village of Alberson, near which is situated the Drake Walls Mine.

Drake Walls is a large tin mine, upwards of three hundred men being employed there. The works above ground are extensive; a more elaborate process for dressing the ore of tin being requisite than is necessary for that of copper. The dressing of tin ore, like that of copper, is, however, effected chiefly by crushing and washing, but the oxide of tin being usually associated with harder minerals than are found in conjunction with copper ore, the use of very powerful and elaborate stamping machinery is necessary for the reduction of the stones to powder. The washing, also, is repeated several times, and by the aid of very curious contrivances, since it is very difficult to entirely free the ore of tin from the particles of foreign matter of nearly the same specific gravity with which it is intermingled.

The separation of ore from its associated minerals is very cleverly accomplished, on a small scale, by "vanning," an operation by which some tinners will distinctly separate from each other three or more minerals. Vanning is performed by means of a shovel, on which has been placed a little of the powdered material, being dexterously agitated with frequent dips into water, until the various minerals have arranged themselves in different places in accordance with their respective specific gravities.

All the Cornish tin is procured from the peroxide, for although tin pyrites, or cupreous sulphuret of tin, does occur in Cornwall, it is rare, and not used for the production of metal. This sulphuret of tin is frequently, from its colour, called bell-metal ore. The peroxide of tin, or ordinary tin ore, is a dark brown, or black mineral, with an adamantine lustre, crystalising in the dimetric system, and having a specific gravity of 7.1.

Besides occurring in lodes, the peroxide of tin is found in old river gravels, and when so found is called "stream tin." Stanniferous gravels are met with in many localities in Cornwall and Devon, in both which counties, in ancient times, the search for stream tin was prosecuted very extensively. The tin stones in these gravels are merely worn fragments of the lodes of the denuded rocks of the district.

Quartz and schorl, or black tourmaline, are the minerals most usually brought up with the ore of tin, though a variety of other substances are sometimes associated with it. Blende and wolfram also occur. The presence of the latter, wolfram, or tungstate of iron, in a tin lode is very undesirable, since the specific gravity of this mineral is quite equal to that of peroxide of tin, and, consequently, the difficulty of the operation of "dressing" is much increased when wolfram forms a portion of the pulverised material.

Peroxide of tin, or "black tin," as it is locally called, is a rich ore. It yields between sixty and seventy per cent. of metallic or "white" tin, and is frequently sold for upwards of £70 per ton.

The total produce of the tin mines of the Duchy of Cornwall, and the number of mines worked in each of ten years, according to the Stannary returns,* will be seen from the following Table:—

Year.	No. of Mines.	Tin Ore.	Metallic Tin.
1860	143	10,400	6,656
1861	148	10,963	7,016
1862	147	11,841	7,578
1863	171	14,224	9,104
1864	174	13,985	9,295
1865	156	14,122	9,038
1866	145	13,785	8,822
1867	117	11,066	7,296
1868	109	11,584	7,703
1869	117	13,883	9,356

Tin mining in Cornwall is of so great antiquity that we find a passage relating to it in the works of Diodorus Siculus, who wrote in the Augustan age. This interesting account of the mining and commercial operations of our ancestors is as follows:—

"We will now give an account of the tin which is produced in Britain. The inhabitants of that extremity of Britain, which is called Belerion, both excel in hospitality, and, also, by reason of their intercourse with foreign merchants, are civilised in their mode of life. These prepare the tin, working very skilfully the earth which produces it. The ground is rocky, but it has in it earthy veins, the produce of which is brought down and melted and purified. Then, when they have cast it into the form of cubes, they carry it to a certain island adjoining to Britain, and called Iktis. During the recess of the tide, the intervening space is left dry, and they carry over abundance of tin to this place in their carts. And it is something peculiar that happens to the islands in these parts lying between Europe and Britain; for at full tide the intervening, passage being overflowed, they appear islands; but when the sea retires, a large space is left dry, and they are seen as peninsulas, From hence, then, the traders purchase the tin of the natives, and transport it into Gaul, and, finally, travelling through Gaul on foot, in about thirty days they bring their burden on horses to the mouth of the river Rhone."—Diodorus, lib. v.†

But ancient as is this record, we have evidence that tin was ob-

* The Stannary returns give only the quantity of ore upon which dues have been paid to the Stannary Court.

† "Some arguments in support of the opinion that the Iktis of Diodorus Siculus is St. Michael's Mount." By Dr. Barham. "Transactions of the Royal Geological Society of Cornwall," vol. iii., p. 120

tained from Britain by the Phœnicians much earlier, though the metal was probably derived during the earliest period from the tin stones of the stanniferous gravels, which even in our days are sometimes profitably worked.

Although the ores of tin and copper are the most important of the minerals of Cornwall, lead, iron, zinc, manganese, silver, and antimony are obtained in very considerable quantities. Indeed, Cornwall is as remarkable for the variety of metallic minerals she possesses as for the abundance of some ; and, in addition to metallic minerals, this county exports great quantities of china clay, granite, serpentine, and other ornamental stones. The following list of Cornish minerals, although I do not give it as a complete or exhaustive catalogue, will serve to indicate the greatness of the mineral resources of Cornwall :—

LIST OF CORNISH METALLIC MINERALS.

(*Synonyms in italics.*)

Tin Ore, *Peroxide of Tin, Cassiterite.*
Tin Pyrites, *Cupreous Sulphuret of Tin.*
Yellow Copper Ore, *Bisulphuret of Copper, Copper Pyrites.*
Grey Copper Ore, *Sulphuret of Copper, Redruthite, Fahlerz.*
Tennantite, *Arsenical Sulphuret of Copper.*
Black Copper Ore, *Black Oxide of Copper, Tenorite.*
Red Copper Ore, *Red Oxide of Copper.*
Malachite, *Green Carbonate of Copper.*
Azurite, *Blue Carbonate of Copper.*
Chrysocolla, *Silicate of Copper.*
Copper Mica, *Hydrous Arsenical Oxide of Copper.*
Aphanesite, *Arsenical Oxide of Copper.*
Condurrite, *Arsenate of Copper.*
Native Copper.
Blende, *Sulphuret of Zinc, Black Jack.*
Cadmiferous Blende.
Calamine, *Carbonate of Zinc.*
Red Hematite, *Peroxide of Iron.*
Brown Hematite, *Hydrous Peroxide of Iron.*
Goethite. *Hydrous Peroxide of Iron.*
Magnetic Iron Ore, *Magnetite.*
Iron Pyrites, *Bisulphuret of Iron, Mundic.*
Wolfram, *Tungstate of Iron.*
Lead Ore, *Sulphuret of Lead, Galena.*
Argentiferous Galena, *Sulphuret of Lead and Silver.*
White Lead Ore, *Carbonate of Lead, Cerusite.*
Pyromorphite, *Phosphate of Lead.*
Mimetene, *Arseniate of Lead.*
Native Silver.
Argentite, *Sulphuret of Silver. Silver Glance.*
Ruby Silver, *Sulphuret of Silver and Antimony, Pyrargyrite.*
Brittle Silver Ore, *Sulphuret of Silver and Antimony.*
Horn Silver, *Chloride of Silver, Kerate.*
Arsenical Silver.
Pyrolusite, *Binoxide of Manganese.*
Psilomelane, *Binoxide of Manganese.*
Wad, *Hydrous Oxide of Manganese.*

Braunite, *Protoxide of Manganese.*
Bisilicate of Manganese.
Grey Antimony, *Sulphuret of Antimony.*
Jamesonite, *Sulphuret of Antimony and Lead.*
Bournonite, *Sulphuret of Antimony, Lead, and Copper.*
Copper Nickel, *Arsenuret of Nickel, Arsenical Nickel.*
Nickel Pyrites, *Sulphuret of Nickel, Millerite.*
Cobalt Bloom, *Arseniate of Cobalt, Erythrine.*
White Cobalt, *Binarsenuret of Cobalt, Smaltine.*
Bismutite, *Carbonate of Bismuth.*
Sulphuret of Bismuth.
Native Gold.

In addition to the above, the following mineral productions of Cornwall may be enumerated:—

Granite
Basalt
Serpentine
Porphyry
Felsparite
Eurite
Kaolin, *China Clay*
China stone
Flag stones
Clay slate
Tungstate of Soda
Plumbago, *Graphite*
Schorl, *Black Tourmaline*
Actinolite, *Hornblende*
Fluor spar, *Fluoride of Calcium*
Beryl
Greenstone
Pitchstone
Talc Schist
Quartz
Cornish Diamonds (*Quartz crystals*)
Red Jasper
Limestone
Arragonite, *Carbonate of Lime*
Celestine, *Sulphate of Strontia*
Heavy spar, *Sulphate of Baryta*
Steatite
Prehnite
Mica slate
Pot stone
Yellow ochre

Leaving Drake Walls, we rise to still higher ground, from which fine and extensive views of the valley of the Tamar are obtained, and mines on all sides afford evidence of the abundant mineral treasures which lie beneath. Higher yet, and we at length come upon the open moor, over which a glorious walk brings us to the summit of Kit Hill, upwards of a thousand feet above the level of the sea, and the highest land in East Cornwall. The downs over which we had passed are called Hingston Downs, from Hengist the great Saxon leader, and it is said that at a place called Horse Bridge, not far distant from Hingston Downs, a battle was fought, and a victory gained by that renowned Chief.

The lower part of Kit Hill is composed of the prevailing rock of the district, an argillaceous slaty rock of Devonian age, and locally called "killas." Granite is, however, not far distant, for as we ascend the hill, and near the summit, it is seen here and there amongst the heather which spreads over the surface; and we find the whole of the upper part of the hill to be granitic. The summit is crowned by the buildings of a large tin mine, while copper mines occur at various points on the flanks.

The view from the summit of Kit Hill is most extensive, embracing the vales of the Tavy and the Tamar, with the lonely hills of Dartmoor beyond; the whole of the south-east corner of Cornwall, with Liskeard and various villages, nestling among the trees; bold granitic hills on the west; and on the north a finely wooded and picturesque country stretching away to the horizon.

East Cornwall forms one of the four great mining divisions of the county. These differ very considerably, not only in the amount of metalliferous ore which each produces, but also in the character of the produce. East Cornwall is principally cupriferous, while the western division is chiefly stanniferous. The west-central is both largely cupriferous and largely stanniferous, and the east-central division is both sparingly cupriferous and sparingly stanniferous.

The amount of tin and copper ore from the mines of each division, on which dues were paid to the Stannary Court during the year 1869 is given in the Table below:—

	Tin Ore.		Copper Ore.	
District.	Weight.*	Value.	Weight.*	Value.
	Tons. cwt. qrs. lbs.	£ s. d.	Tons. cwt. qrs.	£ s. d.
Western - -	2709 20 2 15	191,852 3 0	190 6 2	1,350 16 10
West Central -	8208 5 1 10	578,580 0 8	42,034 13 0	169,551 6 4
East Central -	781 12 3 1	54,630 15 11	464 7 0	1,593 12 0
Eastern - -	599 8 2 12	41,054 12 4	23,657 18 3	121,016 16 5
Sundry Mines -	1456 19 2 0	13,879 0 9		
	13,756 8 3 10	879,996 12 8	66,347 3 1	293,512 11 7

* 21 cwt. to the ton.

These figures, although serving to indicate the relative productiveness of the four great divisions of the county, do not show the total quantity of tin and copper ore obtained in Cornwall during the year 1869. This is computed from the Smelter's Returns to be about 14,590 tons of tin ore, of the value of £1,015,000, and 71,790 tons of copper ore, of the value of £316,364.

Though Cornwall has been divided, for statistical purposes, into four great divisions, upwards of twenty mining districts are enumerated in the "Mining Directory." The mines around Kit Hill, and in the neighbourhood of Calstock, are comprised in the district of which Callington is the principal town, and hence called the Callington District. In the Callington Mining District, in 1869, there were 22 mines, from 19 of which copper was procured; tin from 14, silver from 4, lead from a like number, iron pyrites from two, and arsenical pyrites from one.

We see from this statement that the Callington district is chiefly cupriferous, though largely stanniferous. It is, moreover, argentiferous and plumbiferous; but iron does not appear to be found in this neighbourhood, except as iron pyrites, which is of value only on account of the sulphur it contains. So frequently is the peroxide of tin associated in Cornwall with the bisulphuret of copper, that thirteen of the mines in this district yield both tin and copper, while silver is usually found with lead, argentiferous galena being the ore from which the Cornish silver is chiefly obtained.

A correct estimate of the relative importance of the mining districts of Cornwall can scarcely be obtained from a mere statement of the number of mines in each, since mines differ so greatly in extent. In some only 20, and even a less number of persons are employed; while at others, 300, 500, 700, and even 1000 persons are employed in and about the mining works belonging to one company, and called by a single name. I have, therefore, prepared a list of the mining districts of Cornwall, with the number of persons engaged in mining operations in each district, as far as can be ascertained. This, though the returns are incomplete, will be sufficient to indicate the relative importance of the various districts:—

District.	No. of persons engaged in Mining.		District.	No. of persons engaged in Mining.	
St. Just ...	... 2774		Pool ...	... 2405	*3
Penzance ...	... 242		Redruth ...	... 1845	
Marazion ...	... 270		St. Day ...	... 1879	
Breage ...	... 1538	*1	Scorrier ...	... 520	*1
St. Ives ...	... 605		St. Agnes ...	... 775	*4
Uny Lelant ...	... 1047		Chacewater	... 408	*1
Hayle ...	... 80		Truro ...	... 1841	*1
Gwinear ...	... 100		St. Austell...	... 1305	*4
Crowan ...	... 300		Bodmin ...	... 303	
Wendron ...	... 860	*2	Liskeard ...	... 3232	*2
Camborne ...	... 3810	*1	Callington	... 1162	*6
Tuckingmill	... 930		Camelford...	... 20	

* Returns incomplete. The numerals following the asterisks indicate the number of mines from which returns are wanting.

So many mines are worked for more than one ore, that it is not possible to state the number of persons engaged in Cornwall in procuring any one metal. The following Table will, however, show the relative importance to the county of each of the minerals which are profitably worked in Cornwall. This Table gives the weight and value of the produce of the whole county during the year 1869 :—

	Weight.	Value.	No. of Mines.
	Tons. cwt. qrs.	£ s. d.	
Tin ore	14,590 0 0	1,015,000 0 0	119
Copper ore	71,790 0 0	316,364 9 6	84
Lead ore	9,023 3 0	148,030 0 0	19
	ozs.		
Silver	315,714		
	Tons. cwt. qrs.		
Iron ore	4,619 6 0	1,810 10 6	7
Manganese	1,558 3 0	7,897 15 4	
Zinc ores	848 6 1	2,149 8 8	7
Arsenic (crude)	1,189 1 2	3,737 18 10	17
Wolfram	11 4 3	111 14 5	1
Tungstate of soda	14 2 2	211 17 9	1
Gossans, &c.	357 16 0	256 18 1	3
Iron pyrites	3,258 11 2	2,664 13 10	
Kaolin and China stone	134,200 0 0		

The distribution of the metalliferous ores of Cornwall is a subject of considerable scientific interest, since it is intimately connected with the geological structure of the county. A ridge of more or less elevated land extends through Cornwall from east to west, forming, as it were, a back bone to the peninsula. This range of hills sends off spurs of lesser elevation, which terminate, in some instances, at the sea in bold cliffs. Along the principal ridge are four great masses of granite, which, with some smaller bosses, form the highest land in the county, and are the links in a granitic chain which connects Dartmoor on the east with the Scilly Isles on the west. Around these great masses of granite, and forming the principal part of the county, are spread the sedimentary rocks, which, by the older geologists, and even by Sir Henry De la Beche as late as 1838, were called Grauwacke, but are now classed as Devonian. These rocks for the most part consist of argillaceous slates, termed by the mining population "killas." Both in the killas and in the granite, and, in many cases, extending from the one rock into the other, and so cutting both, are dyke-like veins of a hard felspathic, or quartzo-felspathic, rock of a granitico-porphyritic character, and locally termed "elvans." Many elvans have been traced for several miles, and are ascertained to be sometimes upwards of 300 feet thick, though frequently they are not more than a few feet in thickness. The principal lodes of copper and tin are found to occur either in the killas not far distant from the granitic rocks, or in the granite itself; while in localities, near which there is neither granite nor elvan courses, the lodes are so poor that the ores cannot be extracted with a profit to the miner. But though this is the case with the copper and tin lodes, the ores of lead, antimony, manganese, iron, and zinc occur in quantities sufficient to be profitably worked in localities in which granitic rocks do not appear. Sir Henry De la Beche, in his "Report," after alluding to this fact, says:—"Hence we might infer that the presence of granite or elvan has had considerable influence in promoting the presence of tin or copper ores, which either occur in them or in other rocks in their vicinity; while the granitic influence, if we may use the expression, was not essential to the accumulation of the ores of lead, antimony, manganese, zinc, or iron, in bunches or veins, as the case may be, in quantities to be profitably worked. So far from the ores of lead appearing abundantly in granite, elvan, or in the schistose rocks contiguous to them, the occurrence of such ores, in quantities sufficient to repay the miner for his labour, is very rarely under such conditions in Cornwall and Devon, being, on the contrary, generally removed from them. As far as the two counties above mentioned are concerned, the conditions favourable for tin and copper ores seem unfavourable to those of lead."

The direction in which the mineral veins or lodes traverse the rocks of Cornwall is also worthy of attention, since the subject presents some marked features. It is found that the general direction of the copper and tin lodes, and, indeed, also of the elvan courses, is east and west, or more or less parallel with the granitic chain which runs through the county, and, consequently, with the axis of elevation of the peninsula, if we suppose the longitudinal ridge to be the result of an elevatory force caused by the uprising of the granite.

The main lodes, having a general east and west direction, are crossed by others at nearly right angles, called "cross courses," the metalliferous contents of which are sometimes similar to those of the principal lode, and sometimes dissimilar.

Though these are the general directions of the metal-bearing veins and elvans, their branchings, intersections, and irregularities are much too complicated for either description or discussion in a paper such as this. I may, however, say that the researches of Mr. Hopkins tended to show that fissures would be produced by an elevatory force acting along the line of the granitic hills generally coinciding with the direction and extent of the lodes and elvans; and Sir Henry De la Beche favoured the opinion that the lodes and elvans of Cornwall were filled up fissures produced by such an elevatory force.

The next morning we prepared for the descent of Okel Tor Mine, which it is requisite to effect at an early hour that the gunpowder smoke, occasioned by the blasting going on throughout the day, may be as much as possible avoided. On arriving at the mine, we were first directed to change our clothes for a complete miner's dress, and thus disguised, with candle in hand, we entered the opening to the mine. Each person entering the mine is furnished with a candle, having a mass of wet clay round it, by which it is securely held in the hand, or fastened to the front of the hat whenever it becomes necessary to have the hands free for descending and ascending the ladders. This mine is not, like a coal mine, descended by means of a bucket and rope, for although the ore is brought to bank by these means up the shaft of the mine, the miners and others use vertical ladders, securely fixed to the rock, and placed, not in the shaft up which the excavated material is brought, but in short shafts or "winzes," which connect one level with another at various distances apart; so that after descending vertically a certain distance a horizontal gallery or level is traversed, and then another vertical descent is made, and so on until the bottom of the mine is reached. It must be clearly understood that the metalliferous vein or lode running *vertically* through the rock, and coal occurring in *horizontal layers* or parallel strata, a metallic mine differs in its plan and arrangement very considerably from a coal mine; for while the workings or galleries of a coal mine are many of them on the same level, and have transverse passages all cut through the coal, which forms the *walls* of the passages, the workings of a copper mine are one under another, following the lode which forms the *roof* and *floor* of each gallery, the killas or rock forming the sides, when the lode is cleanly worked out.

In the Okel Tor Mine the workings or levels are excavated at regular distances of 15 fathoms below each other, the first or highest level being 20 fathoms, or 120 feet, below the surface. The mine is not, however, entered by an immediate descent, as we first traverse a horizontal gallery called an adit, which enters the face of the hill. At the inner end of the adit we began to descend, using the vertical ladders. The ladders are very strongly made, and securely fastened by iron staples driven into the rock. No fear need, therefore, be entertained of the ladders slipping or shaking, and a firm, yet not too tight grip of the iron rounds is all that is necessary to enable the descent to be made with perfect safety. Each ladder is not more than 30 feet in length, and at the bottom of it a wooden stage is placed, from which the next descends. This arrangement affords both rest and security during the descent, and thus very great depths are ultimately reached without difficulty or danger. This method of descending, though somewhat laborious, has the advantage of enabling the visitor to obtain a much better idea of the depth of a mine, and of impressing him much more forcibly with the great amount of labour expended in obtaining from the earth its hidden mineral wealth, than is the case when a rapid descent is made in the ordinary way.

Under the guidance of the obliging manager we were taken to every interesting portion of the mine, and shown the mode of working out the lode, which is in some places several yards thick. Although this is not considered a "wet mine," a considerable quantity of water issues from the rock, and runs along the galleries. This however, is by no means a disadvantage, as a receptacle is formed in which the water of the mine is collected, and then pumped to the surface, where it is used for dressing the ore, an operation requiring a large and constant supply of water. As in coal mines, tramways are laid on the floor of each level, and along these small waggons, filled with excavated material, are pushed to the bottom of the shaft. The height of the levels is everywhere such that an averaged sized man may walk upright with comfort, and the air is quite good, no noxious gases being perceptible to the senses. Accumulations of carbonic acid gas sometimes occur, but no explosive gases, such as produce the dreadful coal mine catastrophes, are met with. Copper mining is, therefore, a much less dangerous occupation than coal mining.

The actual work of the mine does not appear to affect the health of the miners injuriously, though the frequent descending and ascending of the ladders produce sometimes diseases of the heart and lungs. One robust old miner, however, working in the lowest level of the mine, told me he had been 40 years at Okel Tor, and he had never had any ill health. Indeed, it is considered by the men to be more pleasant in many respects than above ground outdoor work, since they are not exposed to the heat of the sun, suffer nothing from rain or wind, and in the winter the temperature below is uniformly high, since, in accordance with the well-known law that there is an increase of temperature of 1° Fahr. for every 65 feet of descent below the surface of the earth, mines of all kinds are always warm, some, indeed, of very great depth are so warm that the miners are obliged to work with scarcely any clothing. Much of the lode is not difficult to work with the short picks in use, but often blasting is resorted to in order to remove large masses of killas, quartz, and the harder portions of the lode. After going to the extreme end of the lowest level, we made our way to the bottom of the winze, and ascended to the level above, where other points of interest were shown to us, and explanations given by our excellent guide. Thus successively nearly all parts of the mine were explored, and at one time we were more than the height of the cross of St. Paul's directly under the River Tamar.

On completing the ascent, and gaining the door of the adit, how glorious was the effect of the strong light of the bright sunny day! The woods on the opposite bank, and the brightly gleaming river below, seemed to have added to them a new beauty, an almost unearthly glory, since the eye had last seen them, so much had we become accustomed to the gloom and shade of the subterranean regions in which we had spent so long a time. Indeed, such a scene, beheld under such circumstances, tempts one to use the words Milton puts into the mouth of Adam when relating to Raphael his first experience of earth:—

> "About me round I saw
> Hill, dale, and shady woods and sunny plains,
> And liquid lapse of murmuring streams; by them
> Creatures that lived and moved, and walked or flew;
> Birds on the branches warbling; all things smiled
> With fragrance, and with joy my heart o'erflowed."

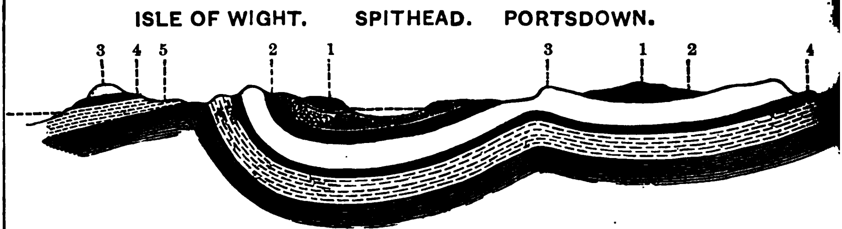
2.—"On the Stratigraphical Distribution of the British Fossil Brachiopoda."

By J. Logan Lobley, Esq., F.G.S.

(The publication of this Paper is deferred.)

No. I.—SECTION FROM VENTNOR TO PE

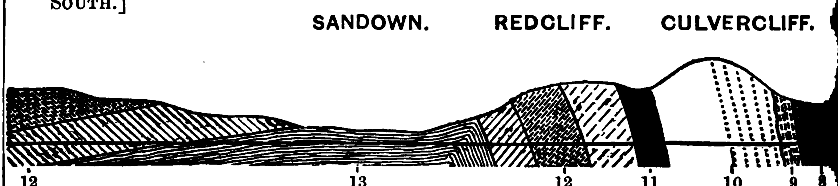
SOUTH.]



1. Upper and Middle Eocene. 2. Lower Eocene. 3. Chalk. 4. Middle Cret

No. II.—SECTION FROM SAND

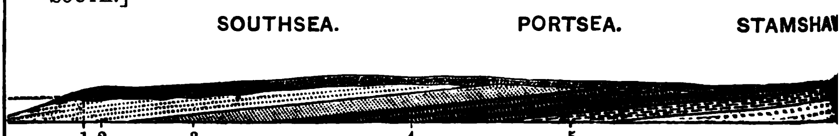
SOUTH.]



1. Gravel. 2. Bembridge marl and limestone. 3. Osborne beds. 4.
8. London clay and Bognor beds. 9. Mottled clay. 10. Ch

No. III.—SECTION FRO

SOUTH.]



1. Gravel 2. Bracklesham beds. 3. Lower Bagshot beds.

) AND FROM MIDHURST TO WATFORD.

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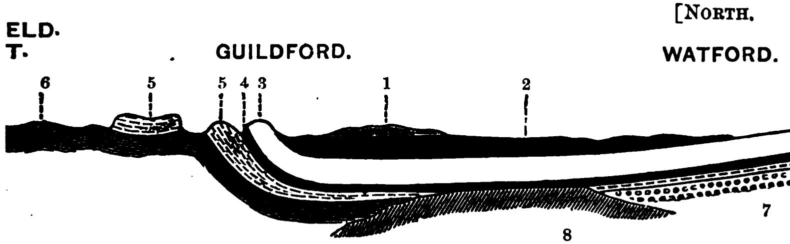
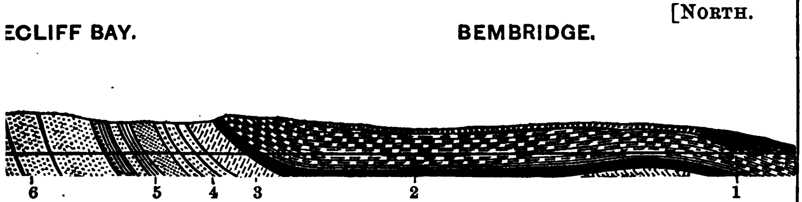


wer Cretaceous. 6. Wealden. 7. Purbeck and Oolitic. 8. Older Rocks.

EMBRIDGE, ISLE OF WIGHT.

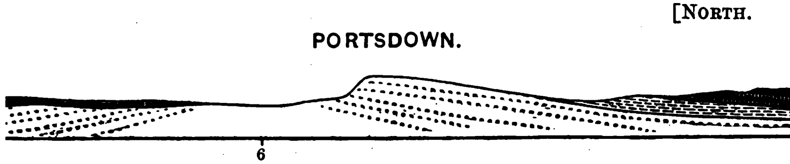
[NORTH.



5. Barton beds. 6. Bracklesham beds. 7. Lower Bagshot beds.
ddle Cretaceous. 12. Lower Cretaceous. 13. Wealden.

EA TO PORTSDOWN.

[NORTH.



on clay and Bognor beds. 5. Mottled clay. 6. Chalk.

ORDINARY MEETING, 4th November, 1870.

Professor Morris, F.G.S., President, in the Chair.

J. Cutherbertson, Esq., was elected a Member of the Association.

The President referred, in very feeling terms, to the death of Edward Cresy, Esq., one of the Vice-presidents, by which the Association had lost an old, a most active, and a highly esteemed member.

Mr. Cresy filled the office of President of the Geologists' Association during the years 1864 and 1865.

The following papers were read:—

1. "On the Structural Characters of the Dinosauria."
By James Murie, Esq., M.D., F.G.S., &c.
(*The Publication of this Paper is deferred.*)

2. "Remarks on the Geological Distribution of the Dinosauria."
By Professor John Morris, F.G.S., President.
(*The Publication of this Paper is deferred.*)

ORDINARY MEETING, 2nd December, 1870.

Professor Morris, F.G.S., President, in the Chair.

The following paper was read:—

"On the British Islands, Past and Present."
By Robert Etheridge, Esq., F.G.S., F.R.S.E.
(*The Publication of this Paper is deferred.*)

ORDINARY MEETING, 6th January, 1871.

Professor Morris, F.G.S., President, in the Chair.

Frank Clarkson, Esq., F.G.S., was elected a Member of the Association.

The following paper was read:—

"On the Geology of the neighbourhood of Portsmouth and Ryde." Part I.

By Caleb Evans, Esq., F.G.S.

Portsmouth, Portsea, Landport, and Southsea, are situated near the south-west extremity of Portsea Island, a flat tract of country, which is separated from the portion of Hampshire to the north of it by a narrow stream connecting Portsmouth and Langston Harbours. The former of these harbours is situated to the west and north of Portsmouth and Portsea, and on the west side of this harbour is the town of Gosport.

Ryde, in the Isle of Wight, is situated nearly opposite the entrance to Portsmouth Harbour, at a distance of about four miles and a half.

It is my intention in the present paper to give a general description of the Tertiary strata exposed in the neighbourhood of these towns, and, in order to render this sketch as complete as possible, I have consulted and made use of the published writings of Mr. Prestwich, Sir Charles Lyell, the Rev. Osmond Fisher, Professor Edward Forbes, Mr. Godwin Austen, Mr. Bristow, Professor Morris, Mr. Codrington, and others.

It is well known that two marked physical features of the south-east of England are the high ranges of hills known as the North Downs and the South Downs. The former of these ranges extends from Farnham to Dover, and the latter from Petersfield to Eastbourne. They are separated in Kent, Surrey, and Sussex by a district occupied by other ranges of hills and intervening valleys, and they are united at the west end by another range of downs, having a general direction from north to south, and extending from near Alton to near Petersfield.

A geological examination of the North and South Downs shows that they both consist of Chalk, with or without flints, and that the strata dip away from the main escarpment of the downs, that is to say, in the North Downs, the escarpment of which faces the south, the inclination of the beds is found to be in general in a northerly direction. The South Downs, on the other hand, have an escarpment facing the north, and the dip of the beds of Chalk is to the south.

It results from this character of the stratification that the deposits occupying the district intervening between these two ranges of downs are in inferior geological position to the Chalk. The Middle and Lower Cretaceous deposits occupy a valley and a range of hills nearly parallel to the Chalk downs, and the central portion of the district consists of fresh-water deposits, known as the Wealden, and forms an undulating tract, in the centre of which is a more or less continuous range of hills extending from near Horsham to Hastings. The various strata have an inclination in opposite directions away from this last range, which is in fact the central portion of a great anticlinal or convex fold of the beds which appear at the surface in the south-east of England. A broad tract of country to the north of the North Downs is occupied by Tertiary deposits, which are bounded to the north and north-west by another range of Chalk hills, extending with occasional interruptions from Dorsetshire to Yorkshire.

In the eastern part of the South Downs the Chalk extends to the sea coast, but from near Bognor, on the east, to near Dorchester, on the west, another Tertiary district intervenes between the Chalk hills and the sea. This district is partly bounded on the south by another range of chalk Downs, which traverses the central portion of the Isle of Wight from Culver Cliffs to the Needles, and the same range is continued in Dorsetshire from Handfast Point to near Dorchester.

The beds of Chalk in the central downs of the Isle of Wight are often in a nearly vertical position, and the Lower Tertiary strata are also highly inclined, but the higher Tertiary beds gradually curve round, and become nearly horizontal.

The Tertiary districts of London and Hampshire occupy synclinal or concave folds of the beds of Chalk, and to the south of the central downs of the Isle of Wight the remains are seen of another anticlinal fold, and another range of downs, the beds of which have a slight inclination to the south, extends from Bonchurch to Niton, the intervening district being occupied by the Middle and Lower Cretaceous, and the Wealden deposits.

The Hampshire Tertiary district is divided into two portions by the arm of the sea, or strait, which separates the Isle of Wight from the mainland. The northern portion is further divided by the irregular arms of the sea forming Southampton Water and Portsmouth, Langston, Emsworth, and Chichester harbours.

About five miles north of Portsmouth, an isolated range of Chalk, known as Portsdown, and extending from near Havant on the east to near Fareham on the west, rises through and is surrounded on all sides by the Tertiary deposits of this area. The various chalk pits opened on the south escarpment of this hill show that, from the London road to near Porchester, the inclination of the strata is in general to the north-east, but further to the west the inclination of the Chalk exposed in a large pit not far from Fareham is to the south-south-west. The sloping tract of country between the foot of the escarpment of Portsdown and the upper part of Portsmouth bours. The former of these harbours is situated to the west and north of Portsmouth and Portsea, and on the west side of this harbour is the town of Gosport.

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Harbour, or Porchester Lake, appears, from the character of the surface, to be occupied by Chalk. It is therefore probable that Portsdown is the northern side of an anticlinal fold of the Chalk, the southern portion of which has suffered much denudation.*

The uniform direction from south to north of the folds, which the Chalk and the Tertiary beds of the south-east of England present, shows that the upheaval or depression of the various districts result, not from local forces acting in a vertical direction, but from a force giving rise to lateral pressure, which had its origin probably in some region more to the southward, since the beds are more contorted in the Isle of Wight than they are in the area to the north of the Solent.†

This force, acting from south to north, is the principal one that has affected the stratification of the Cretaceous and Tertiary beds of the South of England, but it is not the only one to which these deposits have been subjected.

In several localities there is evidence of the existence of anticlinal and synclinal curves, having a direction from east to west. This series of folds can be best seen and examined along the north coast of the Isle of Wight.‡

At several points along this side of the Isle of Wight a hard bed of calcareous rock, known as the Bembridge Limestone, forms a conspicuous feature in the cliffs or on the shore. At the east end of the island the Bembridge Limestone is seen near St. Helen's with an inclination to the east or south-east. Westward of this spot the band rises, and the shore is occupied by beds lower in the series. It is again on the level of the shore near Ryde, and the district between St. Helen's and Ryde thus forms an anticlinal curve. Slight synclinal curves form the valleys by Ryde, Binstead, Wootton Creak, and King's Quay, separated by small intervening anticlinal ridges; and at Osborne the limestone rises with a strong easterly inclination, and lower beds rise in succession on the beach as far as East Cowes. The western side of this anticlinal is not exposed, as a fault in the valley of the Medina has caused a considerable displacement of the beds. Slight curves of the strata are seen at West Cowes, Gurnet Bay, Thorney Bay, and Newtown River, the limestone in some places rising above and in others disappearing below the level of the sea. From Hempstead Ledge to Cliff End

* See Sections Nos. I. & III. † See Section No. I.
‡ See section in "Forbes's Memoir on the Isle of Wight."

near Colwell Bay a considerable synclinal or concave curve exists, the river at Yarmouth occupying the central portion of the depression. It is stated in "Professor Forbes's Memoir on the Isle of Wight,"* that "Each of these curves can be traced across the northern or Tertiary portion of the island, and has a corresponding line of curvature in the central Chalk ridge." Also that "each north and south valley, formed by a synclinal curve of a roll, corresponds to the division between two Chalk downs, and each down to an anticlinal."

These east and west folds are not seen in the low lying district of the opposite coast of Hampshire, and further detailed investigations are required before it can be decided whether or not the whole of the south-east of England has been subjected to flexures resulting from a force acting from the eastward, in addition to the principal one acting from the south.

The various deposits which occupy the Hampshire Tertiary area are well seen in the sections exposed at Whitecliff Bay at the east end of the Isle of Wight, and at Alum Bay at the west end of the same island.

LOWER EOCENE.—The whole of the Lower Eocene deposits are in a highly inclined position in Whitecliff Bay, and most of the beds can be well examined either in the cliff or on the shore between the tide marks.

The junction of the Chalk with the Tertiary beds is not clearly exposed, as that part of the cliff is covered to a considerable extent with vegetation. According to Mr. Prestwich,† who has published a section and description of the beds in Whitecliff Bay, the surface of the Chalk is much worn, and is overlaid by about two feet of yellow sand containing green-coated flints.

Mr. Bristow, in the appendix to Professor Forbes's Memoir, described the junction bed as consisting of from three to four feet of brown sand covering an uneven eroded surface of chalk.

No fossils have been recorded from this bed of sand, and it is therefore uncertain whether it is a deposit subordinate to the bed above it, or is the attenuated representative of one of the subdivisions of the Eocene beds more largely developed in other localities.

The bed which succeeds, although also destitute of animal remains, occupies a clearly defined position in the Eocene series. It

* pp. 14 and 17.

† "Quart. Journ. Geo. Soc.," vol. ii.

consists* in the Isle of Wight of a red clay mottled with blue and brown, which is tenaceous and free from carbonate of lime. This clay increases in thickness in proceeding from west to east. According to Mr. Bristow,† it is at Alum Bay 90 feet thick, and in Whitecliff Bay 163 feet. In the latter locality Mr. Prestwich states it is 140 feet thick. The thickness exposed perhaps varies in different years; when measured in the autumn of 1870, by Professor Morris and myself, the interval between the Chalk and the Ditrupa concretions above the mottled clay appeared not to exceed 120 feet.

This bed of mottled clay is seen at several spots on the mainland near Portsmouth, and is used for making bricks and tiles. It is dug on the shore at a short distance north of the Dockyard extension works; also a little further north at Stamshaw, and the clay is locally known as Stamshaw Clay. It is also worked at Fareham, near the western termination of Portsdown, and at Bedhampton, at the eastern end of that hill; and it is probable that the mottled clay occupies the surface of a belt of country surrounding this elevation of the Chalk. The thickness of the mottled clay in this district has been ascertained by a well, sunk a few years since in Portsmouth Dockyard, to be about 106 feet.

This deposit is remarkable for the great extent of country over which it preserves the same mineral character. It is met with in many localities in the Hampshire Tertiary district, and also in the western portion of the London Tertiary area; but, in advancing northwards from the neighbourhood of Portsmouth, it is frequently associated with beds of sand, and occasionally with beds containing black flint pebbles.

In Sussex the mottled clay‡ is seen to the west of Brighton, and extends by Lancing and Arundel to Botley, north-west of Portsdown.

At a well, sunk at Southampton it was found to be about 80 or 100 feet thick. At Bishopstoke, a few miles north of Botley on the London and South-Western Railway, the mottled clay is replaced by beds of sand and pebbles; but it is again met with at Clarendon Hill near Salisbury, where it is associated with thin beds of sand. Westward of Hampshire red clays with sands and pebble beds cap the Chalk near Lulworth, but towards Dorchester

* Prestwich—"Quart. Journ. Geo. Soc.," vol. iii. † "Memoir Geo. Surv."
‡ Prestwich—"Quart. Journ. Geo. Soc.," vol. x.

the mottled clays nearly disappear, and are replaced by pebble beds and white clays.

In the western portion of the London Tertiary district, as at Basingstoke, Reading, Sonning Hill, and Twyford, similar mottled clays prevail, usually associated with sands. A bed of oysters is very generally present at the base of the group; and Mr. Prestwich has observed a similar layer of oysters in a railway cutting at Kembridge near Romsey, in the Hampshire area. The mottled clays extend to the eastward as far as London, Croydon, and Ewell, and have been met with in the various well-borings in and around the Metropolis.

To the east of London and Croydon the mottled clays, as represented in Hampshire and Berkshire, are imperfectly seen, the greater part being replaced by sands, clays, and beds of pebbles, associated with beds of clay varying in thickness, but abounding with fossils of an estuarine and occasionally of a fresh-water character. These fossiliferous beds are well seen at Charlton near Woolwich, and at Lewisham. To these beds Mr. Prestwich has assigned the name of the "Woolwich and Reading Series."

To the eastward of London thick deposits of sand intervene between the Woolwich Beds and the Chalk. These sands have been named the Thanet Sands, or the Thanet Beds, from the fact that they are fossiliferous in and near the Isle of Thanet. The Thanet Sands, which are the oldest of the English Tertiary deposits, do not appear to be present either in Berkshire or in Hampshire.

The Woolwich and Reading Series is well represented in the neighbourhood of Paris. Several of the Woolwich shells are found at Epernay and Soissons, and the mottled clays "extend over a large portion of the French tertiary area. Hand specimens from Meudon, near Paris, could not be distinguished from Reading or Ewell specimens."*

In Belgium and Northern France the Thanet Beds are about 80 feet thick, and contain fossils similar to those of East Kent, but the Woolwich Series is only represented by unfossiliferous sands.

The absence of fossils in the mottled clays renders it doubtful whether they are of marine or fresh-water origin. Associated as they are with deposits of an estuarine or fresh-water character, it is possible that, as suggested by Mr. Godwin Austen,† they were

* Prestwich—"Ground beneath us."
† Prof. Forbes's "Mem. Isle of Wight," p. 32.

formed in the deeper portions of the fresh-water area in which the Woolwich shells lived; but the general character of the Woolwich shells is estuarine rather than purely fresh-water, and denotes the proximity of a marine area, and the mottled clays may therefore have been deposited beneath salt water.

In the valuable papers of Mr. Prestwich on the Tertiary beds, that gentleman has expressed his opinion that the mottled clays, though contemporaneous with the sands and shelly clays of the Woolwich area, were possibly derived from a different source, and he suggests that the Woolwich shell beds were deposited in the estuaries and along the shores of an island occupying the area now forming the Weald of Kent and Surrey; the pebbles, sands, and clays having been derived from the beds of Chalk, Greensand, and Gault exposed in that island. At the same time, the mottled clays were derived from a large river draining another district of great extent, largely composed of granitic and basaltic rocks, situated to the south-west, and occupying parts of the West of England, of North-Western France, and of the intervening channel area. The climate of this period was probably temperate in character, and lower than that of the succeeding epoch.

Bognor Beds.—Immediately above the mottled clay in Whitecliff Bay there is a band of sandy clay, about three inches thick, containing rounded black flint pebbles, and pebbles or subangular masses of a red material. This band is occasionally concreted, and then forms a conglomerate. This pebble bed is succeeded by about six feet of dark green sand, in which is a band of tabular concretions, containing in great numbers a small tubular shell, known as *Ditrupa plana*. This shell is by some palæontologists considered to have belonged to an annelid, and by others to a pteropodous mollusc.

The pebble bed is occasionally seen in the section at Alum Bay in a similar position, and it, or a similar bed, has a wide extent,* and can be traced from the Isle of Wight to Woodbridge, in Suffolk.

A pebble bed has been observed in Bere Forest to the north of Portsdown, in the railway cutting near Fareham, and at Clarendon Hill, and also at several localities in the western and northern parts of the London district. It occasionally contains fossils, of

* Prestwich—"Quart. Journ. Geo. Soc.," vol. vi.

which the most constant are the teeth of *Lamna*. *Ditrupa plana*, sometimes in sand or clay but in general forming concretionary masses, has been observed at Clarendon Hill near Salisbury in the Hampshire district, and at Sonning Hill near Reading, Hedgerley near Slough, and at other places to the west of London. These concretions and sands often contain other fossils. In Whitecliff Bay the other organic remains of the Ditrupa band are in a bad state of preservation; at Hedgerley and near Reading they can be more accurately determined. These fossils are all of marine forms, and some of them belong to species present in the thick mass of the London Clay which succeeds to this deposit. Mr. Prestwich has named these sands, pebbles, and concretions, the Basement Bed of the London Clay.

In many localities in North and West Kent there is a bed of sand with pebbles, which occupies a very similar position above the Woolwich Series and below the London Clay. At several spots this pebble bed fills hollows in the underlying series, and it is then often of great thickness. These pebble beds are largely developed at Plumstead, Blackheath, Bromley, and Chislehurst in West Kent, and at Shottenden Hill* in the eastern division of the county. Occasionally these beds abound with organic remains, and this is especially the case at Sundridge Park near Chislehurst. The fossils from an old pit in this park have long been known, and during the construction of the adjacent railway tunnel on the Lewisham and Tunbridge branch of the South Eastern Railway, the fossils of these sands were obtainable in great numbers.

The shells found in these pebbly sands, unlike those from the pebble bed of Hampshire and the western part of the London district, correspond rather with those of the beds below than with those of the London Clay above. The fluviatile or estuarine shells of the Woolwich Series (*Cyrena*, *Melania*, &c.), are present in considerable numbers, but are often waterworn, and they are associated with others of a purely marine type (*Pectunculus*, *Nucula*, *Pseudoliva*, *Fusus*, &c.).

By Mr. Prestwich these pebble beds, or a part of them, were considered to be an extension of the Basement Bed of the London Clay; but Mr. Whitaker, in a paper read before the Geological Society in 1866, has classed them as an independent series, intervening in

* Whitaker—"Quart. Journ. Geo. Soc.," 1866.

age between the true Basement Bed and the Woolwich Series, and he has assigned to them the name of the Oldhaven Beds.

In the London district the Basement Bed is succeeded by the thick argillaceous deposit, which, from the fact that it forms the subsoil of a great part of the Metropolis and of its neighbourhood, is known as the London Clay. This deposit consists, in most localities, of a very stiff dark grey or brown clay, with irregular bands of argillo-calcareous nodules, known as septaria. The higher portion of the deposit, which consists of a sandy clay, is seen in the more hilly parts of the neighbourhood of London (Highgate, Hampstead, and Norwood).

Marine fossils are scattered throughout the London Clay, but are most abundant in the higher and sandy portion of the deposit, where, together with many characteristic fossils, others rare in the lower zones prevail, especially *Voluta nodosa* and *Pectunculus decussatus.*

In and near the Isle of Sheppey a local development of the highest portion of this clay has afforded a very remarkable assemblage of organic remains, including mammalia, reptiles, many species of fishes, and great numbers of fruits and nuts belonging to genera which now flourish in the tropics.

In the Hampshire district the pebble bed and the sands with *Ditrupa plana,* before noticed, are also succeeded by a series of argillaceous beds, which in Whitecliff Bay are 295 feet thick.

In the autumn of 1870 I assisted Professor Morris to measure the section of the Lower Eocene series seen in Whitecliff Bay. This section was measured along the shore between high and low water mark, where the edges of many of the strata were finely exposed. The deposit occupying the first 118 feet above the Ditrupa band was not seen on the shore. In the sloping cliff it appeared as clay with septaria, and occasionally green, brown, and ferruginous sands. To these strata succeed argillaceous beds containing in the lower part an oyster of large size, four feet above which is a band of clay, $4\frac{1}{2}$ feet thick, with many specimens of *Panopæa.* Most of these shells are double, and in the normal position in which they lived. About $1\frac{1}{2}$ feet above this there is a zone of *Pinna affinis,* and then about 25 feet of stiff clay with bands of flattened septaria, and a second band of clay, 6 inches thick, with *Panopæa* follows. In the next 20 feet *Cyprina planata* is the prevailing shell, and this species is also present in the succeeding 25 feet of clay, together with *Panopæa* near the upper part. Thirty feet of clay with zones of septaria separate these strata from a deposit, which was concealed on the shore, but appeared in the cliff as a bed of ferruginous yellow false-bedded sand with laminated clays and sands above and below. The next bed denotes a change and increase in the transporting power in which this series originated. It consists of six inches of clay containing rounded flint pebbles, above which are 36 feet of stiff sandy clay with zones of septaria, containing the remains of shells imperfectly preserved. This clay terminates the Lower Eocene deposits as represented in Whitecliff Bay.

A very similar series of argillaceous deposits is seen in Alum Bay, where it has been measured by Mr. Bristow ;* in this locality a band of small black pebbles has been noted about 29 feet from the top of the series, below which are 7½ feet of bluish-green clayey sand with three bands of scattered nodules of argillaceous ironstone, and the lower portion of the group consists of beds of sandy clay and clayey sand, with septaria ; the total thickness of the series is 199 feet 8½ inches.

The organic remains, recorded from these beds in the Isle of Wight, closely correspond with those met with in the clays and in the blocks of calcareous sandstone seen on the shore near Bognor in Sussex. Several of these Bognor fossils are also met with in the London Clay of the London district.

On the mainland of Hampshire I am not aware that any extensive exposure of beds, equivalent to these "Bognor Beds," is seen at the surface, as the coast sections only show strata higher in the series, and the inland outcrop of these beds is in general concealed by superficial deposits.

Within the last few years very fine and extensive sections of beds, corresponding with a portion of the Bognor Series of the Isle of Wight, have been brought to light in the works now being carried on for the enlargement of the docks at Portsmouth. These docks are being excavated below the level of that part of Portsmouth Harbour immediately to the north of the town of Portsea, which is known as Fountain Lake.

I have from time to time, since the commencement of these works, visited them by the kind permission of my friend Mr. Christian

* Mem. Geo. Surv.

Meÿer, one of the engineers employed in the construction of the docks, and in the autumn of last year (1870), I made a more detailed examination of some of the sections then exposed, and on that occasion I enjoyed the great privilege of visiting the works frequently in company with Professor Morris.*

The details of these sections have lately been communicated to the Geological Society, by Mr. Charles Meÿer, F.G.S.†

The Eocene beds seen in the dockyard works have a nearly uniform inclination at a slight angle in a direction a little to the west of south. The mottled clay has not been exposed in the open excavations, nor has it been reached in the experimental boring which was being made at the time of my last visit. This boring was carried to the depth of 147 feet from the bottom of one of the cuttings. The lowest bed reached consisted of a stiff dark coloured clay, which was traversed through a thickness of 45 feet. At one level this clay contained fragments, described by the workmen as resembling chaff. These fragments were probably the remains of the fibrous shell of a *Pinna.* Above this clay is a bed of light grey sand, 15 feet thick, containing black flint pebbles in the upper part. From this sand a copious spring of fresh water rose to the top of the bore hole, and overflowed the surface of the cutting. Above this sand is a second bed of stiff dark coloured clay, 78 feet thick, containing *Actæon*, *Pleurotoma*, and *Cyprina* or *Cytherea.* The highest part of the boring passed for a depth of nine feet through an argillaceous sand similar in mineral character to the lowest bed seen in the adjacent cuttings.

The deposits in these cuttings are exposed in an admirable manner, and very clear vertical sections of the strata can be examined with great facility. The lowest beds in these sections consist of dark greenish sands about 40 feet thick, of which the lower portion is the most argillaceous. A band of light coloured micaceous sand, about three inches thick, is very conspicuous in the upper part of the argillaceous sands, and there are about four bands of large argillo-calcareous concretions or septaria interstratified with the sands.

Organic remains are not so abundant in the lower or argillaceous portion of these green sands as in the upper eight feet of the

* See a valuable letter by Professor Morris, in the "Hampshire Telegraph," for 24th Sept., 1870.

† "Quart. Journ. Geo. Soc.," vol. xxvii., p. 74.

deposit, and there is some difference in the character of the fossils. The fauna of the lower beds includes *Cardium*, *Solen*, *Nucula*, *Cytherea*, *Panopæa*, *Pholadomya*, *Modiola*, *Voluta*, *Fusus*, *Rostellaria*, *Pleurotoma*, *Aporrhais*, *Natica labellata*, and *Dentalium*.*

The highest portion of these sands and the highest band of nodules contain a great abundance of fossil shells in an excellent state of preservation. A few feet below the top of the sands there is a thin layer containing great numbers of *Cytherea proxima*, occasionally double but usually as single valves. These shells are frequently perforated by some carnivorous Mollusc, probably by a species of *Natica* (*N. subdepressa*), which is also very abundant at this level. This shell-band can often be traced through the calcareous nodules. Another common shell is *Pyrula Smithii*, which is often found of large size. Among the other fossils of this sand may be mentioned *Cytherea orbicularis*, *Cardium Wateleti*, *Cardita planicosta* (?), *Nucula gracilenta*, *Cassidaria diadema*, *Solarium bistriatum*, *Trophon tuberosum*, *Voluta elevata*, several species of *Fusus* and *Pleurotoma*, *Rostellaria lucida*, *Calyptræa trochiformis*, *Sigaretus*, *Turritella*, *Nautilus*, *Spatangus*, several species of Crustacea, and fragments of plants. This portion of the sands is also remarkable for the abundance of *Lingula tenuis*, a Brachiopod which is common at Bognor, and occasionally found in the London Clay of the London district. Above the band with *Cytherea proxima* these sands contain great numbers of *Panopæa intermedia*, in the vertical position in which they lived.

A marked change in the mineral character of the beds takes place at the top of these fossiliferous sands. They are succeeded by about four inches of clay full of rounded flint pebbles, above which is a bed of similar dark brownish clay with bands of septaria. This deposit closely resembles in mineral character the London Clay of the metropolitan area. About 35 feet of the clay is exposed.

This clay contains *Panopæa corrugata*, *Pholadomya*, *Cyprina planata*, *Cytherea*, *Pectunculus*, *Pinna affinis*, *Pecten corneus*, *Nautilus centralis*, and wood perforated by the *Teredo*. There is also a thin band with broken fragments of *Pinna*. The pebble bed contains the teeth of *Lamna*.

* Since this paper was read excavations have been made (1871) in the sands intermediate in position between the sands with Dentalium and the sands with Lingula. From these excavations many crustacean remains have been obtained, chiefly of the type described by Mr. Woodward under the name of *Rhachiosoma*, in "Quart. Journ. Geo. Soc.," vol. 27.

The most abundant species of shells met with in the dock excavations are four or five in number; of these *Cyprina planata*, a well-known fossil of the London Clay, is common in the clay above the pebble bed. *Pholadomya margaritacea* (?) and *Panopæa corrugata*, abound in the clay associated with the pebbles, and are there seen in the position which they occupied when living, and *Panopæa intermedia* is seen in position in great numbers in the sands immediately below the pebble bed.

The sands contain the greatest variety of fossils, several of which are new to science, or have not hitherto been met with in British strata; among the latter is *Cytherea proxima*, so abundant at this level.

The *Natica*, which is also very abundant in this part of the section, is considered to be identical with *Natica subdepressa*, a fossil first described by Professor Morris.* This species has been found in the Thanet Beds of East Kent—the lowest member of the English Eocene—and a very similar shell has been met with in the pebbly sands of Sundridge Park; the species is also recorded from the Bognor Rock.

Of the other fossils of these sands several appear on the first view to correspond with well-known forms belonging to the Middle Eocene, but on examination many of these specimens prove to be distinct.

The species, the identity of which with known British fossils can be determined, are nearly all restricted to the Lower Eocene division, and correspond in many instances with the fossils recorded from the Bognor rock and clay, and with those obtained from the deep well boring at Southampton. It is probable, therefore, that the Portsmouth beds now under consideration have a considerable extension both to the eastward and westward of that town. There are, however, no clear sections on the mainland which show the stratigraphical position or the thickness of these deposits, except well-borings, and it is consequently necessary to compare the Portsmouth beds with those of the coast section in Whitecliff Bay, in order to determine their exact position in the series.

The mineral character of the clay at Portsmouth, and of the pebbles embedded in its lowest portion, so closely resembles that of the London Clay and of its pebbly Basement Bed, as seen at Lewis-

* "Quart. Journ. Geo. Soc.," vol. x.

ham and other spots in the London district, that the attention of an observer is first directed to the deposits in Whitecliff Bay, assigned by Mr. Prestwich to that horizon. The pebble bed, which is supposed to represent the Basement Bed in Whitecliff Bay, rests immediately on the mottled clay, and has above it about six feet of dark green sand, containing the concretions with *Ditrupa plana*. In these respects the Portsmouth pebble bed differs from that at Whitecliff Bay, as at Portsmouth the pebbles are included in the clay, and the sandy beds are below them. Moreover, the mottled clays, which are immediately below the pebble bed, and only a few feet below the lowest of the argillaceous beds at Whitecliff Bay, have not been reached in the Portsmouth excavations, and the experimental boring undertaken by the surveyor of the works shows that argillaceous strata (with some subordinate sandy beds), at least 180 feet in thickness, intervene between the pebble bed exposed in the dockyard works and the mottled clays.

These facts compel us to look higher in the Whitecliff series for the equivalents of the dockyard beds. According to the details already given of the Whitecliff Bay section, the highest member of the argillaceous or Bognor Series is a stiff sandy clay with zones of septariæ 36 feet thick, at the bottom of which is a band of clay, six inches thick, containing many black flint pebbles, and below this band are beds of laminated clays and sands, in the centre of which is a bed of ferruginous yellow sand; lower in the series are beds of clay, characterised by the abundance of *Cyprina*, and yet lower is a zone with *Pinna*.

Notwithstanding the distance intervening between Whitecliff Bay and Portsmouth, there is a striking correspondence between the sections at these two spots, if the upper pebble bed of the Whitecliff section is considered to be the same bed as the pebble bed exposed at the Portsmouth works.

The section at Alum Bay, at the west end of the island, shows a very similar succession of deposits, but of diminished thickness.

The whole of this evidence leads to the conclusion that the dockyard beds correspond with beds occupying a high position in the Lower Eocene series of the Hampshire district, and that they are closely related to the Bognor rock and clays of Sussex.

The Bognor Beds are very generally considered to be of the same age as the London Clay, seen in the neighbourhood of the metropolis; but there are several important characters in which this

Hampshire group differs from the London Clay. The latter, in the neighbourhood of London, is argillaceous in character, except in the highest part, and, as far as is known, pebbles occur only at the base of the deposit. In the Bognor Series of Hampshire the deposition of pebbles was repeated at least three times, and the whole group consists of alternations of sands and clays. Although several of the fossils of the Portsmouth and Bognor beds are also met with in the London Clay, most of these belong to species which are not common in or typical of the latter bed. Other species correspond with fossils of the Lower London Tertiaries, and several of the most abundant shells of the Portsmouth beds have not hitherto been recognised elsewhere in England, but have been identified with fossils from the Lower Tertiaries of France. These differences render it doubtful whether these Hampshire beds are exactly synchronous with the London Clay, and it is, therefore, desirable to retain for them the name of "Bognor Beds," rather than that of "London Clay," as the latter term suggests a correlation which is open to question.

The London Clay is not represented in the Tertiary series of Paris, but a bed of clay seen in the upper part of a cliff near Dieppe is supposed to be an extension of this formation. The London Clay is of considerable thickness in Belgium and Northern France; but becomes gradually thinner as it ranges to the southward.

Mr. Prestwich* considers that the fossils of the London Clay indicate the existence of a warm climate during the period of its deposition, but not so tropical as that of the Middle Eocene age, and he suggests that the sea of this epoch was open to the north, and bounded by a coast line to the southward.

* "Quar. Jour. Geo. Soc.," vol. ii., p. 231.

"On the Stratigraphical Distribution of the British Fossil Brachiopoda."

By J. Logan Lobley, F.G.S.

(*Read July* 1*st*, 1870.)

At the meeting of the British Association, in 1868, I read a paper "On the Distribution of the British Fossil Brachiopoda," and in the "Geological Magazine" for November in the same year, appeared a summary of the results stated in that paper. The present paper contains a more detailed and systematic statement of these results than it was possible to give in the brief communications above mentioned, together with those modifications and additions which the progress of research has rendered necessary.

It can always be objected to Palæontological statistics that they are merely provisional, and only approximately correct, that conclusions based upon them can scarcely be final, and that since no two authorities agree in their determination of species, or in their definition, nomenclature, and classification of genera, the details of these statistics are especially open to dispute and objection.

It may, however, be contended that it is very desirable as well for students as for older palæontologists and general geologists, to have presented to them a synoptical view of what has been achieved in any one branch of palæontological research and investigation, that they may be able to obtain a knowledge of ascertained facts and general results without that great expenditure of time which would otherwise be necessary. So much, too, has been done by earnest and able workers with hammer, and microscope, and pen, during the last twenty years in the exploration of the fossiliferous rocks of the British Islands, and in the determination and description of their organic contents, that the present, much more than any past time, seems to be appropriate for the presentation of such synopses and summaries of results.

If this be true with respect to the fauna and the flora of British strata generally, it is especially true of the class Brachiopoda. Though we cannot hope for certainty in the determination of many species, and though every year will materially extend our knowledge of the fossil Brachiopoda of these islands, yet much has already been done towards establishing upon a permanent footing the nomenclature and classification of this interesting and important class.

We are greatly indebted to the investigations of Dr. Carpenter and Professor Morris for our knowledge of the shell structure of the Brachiopoda, upon which have been based many important determinations. The more recent labours of Mr. Charles Moore, Mr. R. Tate, Mr. Walker, Mr. Seeley, Mr. Meÿer, Mr. Hicks, and others, have added largely to our knowledge of the distribution of species and range of genera. But beyond, and above all, we are indebted to the unwearied researches of Mr. Davidson, whose great work on the Brachiopoda, the result of the labour of twenty years, has just been completed.

To Mr. Davidson my acknowledgments are most especially due, for his researches have rendered it a comparatively easy task for me to give the summary contained in the following pages, and the completion of the "Monograph of the British Fossil Brachiopoda" has been of invaluable service to me while revising my lists of species and constructing the tables which accompany this paper.

Though my lists of species have been to a very great extent founded on Mr. Davidson's determinations, they yet contain many names which will not be found in his great work. These names are chiefly those of Cretaceous and Jurassic species, which have been described subsequently to the publication of the parts of the monograph devoted to the Mesozoic Brachiopoda. And as, too, my information has been derived from numerous sources, some of which give the results of very recent explorations, species will be found from the tables to have stratigraphical ranges more extended than indicated in Mr. Davidson's monograph. On the other hand, many familiar names will be missed. These are names now discarded, either from generic appellations having been changed in accordance with more extended information, from its having been ascertained that other names had previously been given, or from so-called species having proved to be merely varieties of typical forms.*

The class Brachiopoda of Cuvier (1805), or Pallio-branchiata of De Blainville (1814), is represented in British strata by 53 genera and sub-genera, and by 649 species,† the names of all which

* With the view of assisting students who may have in use works not the most recent, a list of synonyms was prepared, and it was intended to add this synonyma to the present paper, but in the last part of Mr. Davidson's monograph a list of synonyms of all the older species has been given, and as such a list is very lengthy, containing upwards of 3,000 names, it has been deemed advisable to omit the publication here of the one I had prepared, and to refer the student to the list above-mentioned, which has been compiled with great care by our President, the Rev. Thomas Wiltshire, M.A. (Sept. 1871.)

† Exclusive of Budleigh Salterton Species, see page 130.

genera and species will be found in Table I., arranged in the order of the incoming, or earliest appearance of each genus.

SPECIES.

(See Table I.)

Except in a comparatively small number of cases, species have not been found to have very extended stratigraphical ranges. The following list contains the names of those species, which appear to have enjoyed the longest term of existence in this area, with the ascertained stratigraphical range of each :—

Athyris phalæna, *Phill.*, L. Devonian to Carboniferous Limestone.
Atrypa desquamata, *Sow.*, L. Devonian to U. Devonian.
,, imbricata, *Sow.*, Caradoc to Wenlock.
,, marginalis, *Dal.*, Caradoc to Wenlock.
,, reticularis, *Linn.*, L. Llandovery to Carboniferous Limestone.
Chonetes Hardrensis, *Phill.*, L. Devonian to Carboniferous Limestone.
,, minima, *Sow.*, U. Llandovery to Ludlow.
,, striatella, *Dal.*, U. Llandovery to Ludlow.
Crania implicata, *Sow.*, U. Llandovery to Ludlow.
Cyrtia exoporrecta, *Dal.*, L. Llandovery to Ludlow.
Discinia rugata, *Sow.*, U. Llandovery to Ludlow.
,, nitida, *Phill.*, U. Devonian to Permian.
Leptæna sericea. *Sow.*, Llandeilo to Wenlock ?
,, transversalis, *Dal.*, Caradoc to Wenlock.
,, quinquecostata, *M'Coy*, Caradoc to U. Llandovery.
,, scissa, *Salt.*, Caradoc to U. Llandovery.
Lingula Symondsii, *Salt.*, U. Llandovery to Ludlow.
Megerlia lima, *Defr.*, Gault to Chalk.
Merista plebeia, *Sow.*, M. Devonian to Carboniferous Limestone.
Meristella didyma, *Dal.*, U. Llandovery to Ludlow.
Orthis Actoniæ, *Sow.*, Llandeilo to U. Llandovery.
,, calligramma, *Dal.*, Llandeilo to Wenlock.
,, elegantula, *Dal.*, Llandeilo to Ludlow.
,, insularis, *Eich.*, Llandeilo to U. Llandovery.
,, biforata, *Schl.*, Llandeilo to Wenlock.
,, hybrida, *Sow.*, Caradoc to Ludlow.
,, biloba, *Linn.*, Caradoc to Ludlow.
,, testudinaria, *Dal.*, Llandeilo to L. Llandovery.
,, Michelini, *L'Eveille*, L. Devonian to Carboniferous Limestone.
Pentamerus undatus, *Sow.*, L. Devonian to Wenlock.
Rhynchonella borealis, *Schl.*, L. Llandovery to Ludlow.
,, nucula, *Sow.*, L. Llandovery to Ludlow.
,, plurodon, *Phill.*, L. Devonian to Carboniferous Limestone.
,, reniformis, *Sow.*, M. Devonian to Carboniferous Limestone.
,, acuminata, *Mart.*, M. Devonian to Carboniferous Limestone.
,, bifera, *Phill.*, M. Devonian to Carboniferous Limestone.
,, pugnus, *Mart.*, M. Devonian to Carboniferous Limestone.
,, variabilis, *Schl.*, L. Lias to Inferior Oolite.
,, varians, *Schl.*, Inferior Oolite to Coralline Oolite.

Rhynchonella obsoleta, *Sow.*, Inferior Oolite to Coralline Oolite.
,, depressa, *Sow.*, L. Greensand to Chalk.
,, latissima, *Sow.*, L. Greensand to Chalk.
,, unciformis, *Sow.*, L. Greensand to Chalk.
Spirifera elevata, *Dal.*, U. Llandovery to Ludlow.
,, crispa, *His.*, U. Llandovery to Ludlow.
,, lineata, *Mart.*, M. Devonian to Carboniferous Limestone.
,, Urii, *Flem.* ? M. Devonian to Permian.
Spiriferina cristata, *Schl* , L. Devonian to Permian.
Streptorhynchus crenistria, *Phill.*, L. Devonian to Carboniferous Limestone.
Stricklandinia lirata, *Sow.*, L. Llandovery to Wenlock.
Strophalosia productoides, *Murch.*, M. Devonian to Carboniferous Limestone.
Strophomena compressa, *Sow.*, Llandeilo to U. Llandovery.
,, rhomboidalis, *Wilck.*, Caradoc to U. Devonian.
,, antiquata, *Sow.* ? Caradoc to Wenlock.
,, pecten, *Linn.*, ? Caradoc to Wenlock.
,, imbrex, *Pand.*, var. semiglobosa, *Dav.* ? Caradoc to Wenlock.
Terebratula sacculus, *Mart.*, M. Devonian to Permian.
,, intermedia, *Sow.*, Inferior Oolite to Coralline Oolite.
,, biplicata, *Brocchi.*, L. Greensand to Chalk.
,, sella, *Sow.*, L. Greensand to Chalk.
Terebratulina striata, *Wahl.*, L. Greensand to Chalk.
Thecidium rusticum, *Moore*, L. Lias to U. Lias.
,, triangularis, *D'Orb.*, L. Lias to Coralline Oolite.
,, Moorei, *Dav.*, L. Lias to U. Lias.
,, Bouchardii, *Dav.*, L. Lias to Inferior Oolite.
Waldheimia ornithocephala, *Sow.*, Inferior Oolite to Coralline Oolite.
,, impressa, *V. Buch.*, Inferior Oolite to Oxford Clay.
,, obovata, *Sow.*, Great Oolite to Coralline Oolite.
Zellaina Davidsoni, *Moore*, L. Lias to Inferior Oolite.
,, Laboucherei, *Moore*, L. Lias to Inferior Oolite.

A very large number of species, as will be seen from an examination of Table I., are confined to single formations, or minor groups of strata; some, indeed, appear to be still further restricted, and to characterise certain zones, though it is to be expected that further exploration of our fossiliferous rocks will much modify the prevalent belief in the restriction of the range of species.

GENERA AND SUB-GENERA.

(See Table I.)

ACROTRETA, Kutorga, 1848. One species.

Though Acrotreta has been placed as a sub-genus of Siphonotreta, and in the family Discinida, its true generic and family affinities are doubtful, as the interior characters are unknown. In general appearance, Acrotreta resembles Cyrtia, but that genus may be readily distinguished by the exterior of the foraminal tube, as well as by the articulation of the valves, which in Acrotreta, as in all the Discinidæ, are unarticulated. Acrotreta has a false area, with a groove terminating at the extremity of the beak, which is perforated by a foramen. The apical foramen of Acrotreta can no longer, however, be considered a distinguishing character, since a species of Cyrtia, possessing a foramen at the extremity of the beak, has recently been described.

One species only of Acrotreta has hitherto been found in the British area. This was discovered by Dr. Nicholson, in 1867, at Dobb's Linn, near Moffat, in strata considered to be of Upper Llandeilo age. In Russia three species have been found in Lower Silurian strata, to which rocks Acrotreta appears to be restricted.

ARGIOPE, Deslongchamps, 1842. Three species.

This is a small, but well-marked genus of the family Terebratulidæ. Argiope is characterised exteriorly by a large foramen, and interiorly by a large loop attached either to a single septum, or to three nearly parallel septa, proceeding inwards from near the margin of the dorsal valve.

In the British area, Argiope has *A. megatrema*, Sow., and *A. Bronnii*, De Hag., in Upper Cretaceous strata; and *A. cistellula*, S. Wood, in the Coralline Crag of Sutton. The genus has a more extended stratigraphical range on the continent of Europe, and further exploration will doubtless result in giving to science species from the British Oolites; but at present we can only indicate the presence of Argiope in our area in Upper Greensand, Chalk, and Older Pliocene strata.

Argiope cistellula was found living in the seas of the Hebrides, in from thirty to forty fathoms water.* The genus has representatives living in the Mediterranean, and in the seas around Madeira and the Canary Islands, and flourishing, according to Dr. S. Woodward, in waters from 30 to 105 fathoms in depth.

ATHYRIS, McCoy, 1852. Twenty-one species.

The genus Athyris is a member of the family Spiriferidæ, with a foramen so generally concealed that a name was given by McCoy to indicate its absence. So much dissatisfaction has been expressed with McCoy's name that several designations (Spirigera, Cleothyris, Merista, Meristella) have been proposed to include either all or

* The information respecting recent Brachiopoda, given in these pages, is chiefly on the authority of the late Dr. S. Woodward, whose "Manual of the Mollusca" should be in the hands of all students of Palio—as well as of Caino—Zoology.

some of the species usually called Athyris. Of these, Merista and Meristella may be considered to be established, but Spirigera and Cleothyris have not been equally successful.

Athyris is confined to our Palæozoic rocks, commencing with the Wenlock, ranging to the Permian, and having its maximum specific development in the Carboniferous Limestone, from which twelve species have been described. The Permian species *A. pectinifera*, Sow., of the Magnesian Limestone of Durham, is also found in the German "Zeichstein."

ATRYPA, Dalman, 1827. Thirteen species.

By several characters Atrypa is allied to the Rhynchonellidæ, and was placed in that family by Dr. Samuel Woodward, but the possession of calcified spiral processes seems to give the genus a good claim to a place in the Spiriferidæ. The name Atrypa is another zoological misnomer, since it implies that the genus is imperforate, when such is not the case. The small incurved beak frequently conceals the foramen, which, however, undoubtedly exists.

Atrypa is, like Athyris, strictly characteristic of British Palæozoic rocks, and appears to be confined to Silurian and Devonian strata, though the well-known *A.* reticularis is said to have been found in Lower Carboniferous rocks. Three species appear in Caradoc, three in Lower Llandovery, five in Upper Llandovery, three in Wenlock, and one in Ludlow rocks; while we have four in the Lower, six (the maximum number) in the Middle, and three in the Upper Devonians.

CALCEOLA, Lamarck, 1809. One species.

I have had considerable doubt whether or not to include the *Calceola sandalina*, Linn., in my lists of species of Brachiopoda. The species is so abnormal, and so coralline in structure, that we cannot with certainty say that it is a Brachiopod; and, indeed, Calceola was excluded from the list of genera given in my paper in the "Geological Magazine" in 1868. Since, however, it has been for a long time placed in the class, and although Professors Suess and Lindström dispute its claim to this position, it has not yet been finally determined to belong to any other class, it will perhaps be better to allow Calceola to retain at present its old place as a characteristic Middle Devonian Brachiopod.

CAMAROPHORIA, King, 1844. Six species.

This member of the Rhynchonellidæ possesses so many points of resemblance to the typical genus Rhynchonella that it may by some be considered a sub-genus. Camarophoria, however, occupies a place between Rhynchonella and Pentamerus, with which latter genus it agrees in possessing converging dental plates.

Camarophoria is essentially Palæozoic, ranging from the Middle Devonian to the Permian. The *C. rhomboidea*, our earliest species, has been found at Barton, Lummaton, and Woolborough, in Middle Devonian rocks. This species also occurs in the Upper Devonian. In the Carboniferous Limestone we find four species, two of which, *C. crumena*, Mart., and *C. globulina*, Phill., occur in the Permian Magnesian Limestone, from which a third species, *C. Humboldtonensis*, House, has been described.

CHONETES, Fischer, 1837. Nineteen (?) species.

Outwardly, with the exception of the presence of tubular spines, Chonetes resembles the Orthidæ, and McCoy placed it as a sub-genus of Leptæna. The internal characters, in the opinion of Mr. Davidson, sufficiently differentiate Chonetes from all the members of Orthidæ, and place the genus as one of the Productidæ, near to Strophalosia.

Chonetes is the earliest member of the family Productidæ, and another essentially Palæozoic genus. It commences with two species, *C. minima*, Sow., and *C. striatella*, Dal., in the Upper Llandovery, and these species recur in Wenlock and Ludlow rocks, with the addition in the latter of *C. lepisma*, Sow. The *C. Hardrensis* passes through all the divisions of the Devonians, and into Carboniferous strata. In the Middle Devonian we have also *C. minuta*, Goldf. A great increase takes place in the Carboniferous Limestone, from which twenty or thirty so-called species have been described. The careful examination by Mr. Davidson has reduced this number very considerably, and of the nineteen species given in Table I. five or six are doubtful, and require further attention. Though the maximum specific development of Chonetes occurs in the Carboniferous Limestone, the range of the genus appears to terminate in that formation, no species of Chonetes having with certainty been found in higher rocks.

CRANIA, Retzius, 1781. Nineteen species.

The hingeless and patelliform genus Crania is so distinctly separated by its characters from all other genera, that it forms a separate family, the Craniadæ.

The range of this genus is one of the most extended of the Brachipoda. We find Craniæ in every system of our Palæozoic and Mesozoic rocks, and we have Craniæ living in our present seas. The genus is, however, absent from our Tertiary deposits, fossil British Craniæ not having been found in strata above the Chalk. Crania commences, in the British area with *C. divaricata*, McCoy, of the Caradocs of North Wales and Ireland. This species is followed by *C. implicata*, Sow., which appears first in Upper Llandovery strata, but recurs in Wenlock and Ludlow rocks. *C. Grayi*, Dav., and *C. Siluriana*, Dav., also occur in Upper Silurian. No Crania has yet been described from the Devonian rocks, but in the Carboniferous Limestone three species have been found, and one *C. Kirkbyi*, Dav., in the Magnesian Limestone of Tunstall Hill. To the labours of Mr. Charles Moore we are indebted for several species. The genus, however, appears to be absent from our Upper Oolites. The Lower Greensand yields *C. cenomanensis*, D'Orb., and the Chalk *C. Ignabergensis*, Retzius, and *C. Parisiensis*, Defrance. The strata above the Chalk have not hitherto yielded a single species of Crania, although, as before stated, the genus is found living in our present seas.

CYRTIA, Dalman, 1827. Two species.

Cyrtia cannot be considered as other than a sub-genus of Spirifera, from which it differs chiefly in possessing a tubular foramen. As Mr. Davidson is of opinion that *C. trapezoidalis* is a synonym of *C. exporrecta*, we cannot at present place more than two species in British strata. The second, *C. nasuta*, may eventually be found to belong to another genus, and indeed the position of the foramen would seem to separate it from Cyrtia. No species of this genus or sub-genus having been found above our Ludlow rocks, Cyrtia must be considered to be essentially Silurian.

CYRTINA, Davidson, 1858. Seven species.

This is another genus or sub-genus about which considerable doubt has existed. Although concluded to belong to Spiriferidæ the internal spires had not been found when the genus was constituted. Cyrtina was proposed by Mr. Davidson to receive certain species which had been placed in Cyrtia, but which differed from the type species of that genus, not only in the shell structure being punctate, but in possessing a peculiar arrangement of internal plates. McCoy's *Pentamerus carbonarius* was also placed in Cyrtina.

Of the seven British species four are in the Middle Devonian and three in the Carboniferous Limestone. Cyrtina is, therefore, essentially Palæozoic.

DAVIDSONIA, Bouchard, 1849. One species.

Davidsonia, named after the great English investigator of the Brachiopoda, is a member of the family Orthidæ, though it was proposed to constitute from this genus a sub-family, the Davidsonidæ.

The genus is represented in British rocks by its type species only, *D. Verneuillii*, Bouch., of the Middle Devonian. This species is characteristic of the Continental Devonians, and is a well-known Eifel fossil.

DISCINA, Lamarck, 1819. Twenty-seven species.

This, the principal genus of the family Discinidæ, is like Crania unarticulated and pattiliform, but differs from that genus in having a foramen for the passage of a pedicle.

The range of Discina, like that of Crania, extends from the Lower Silurians to the Recent, and as *D. Pileolus* has been found by Mr. Hicks in Cambrian rocks, Discina may be stated to possess a longer range than any other genus of Brachiopoda. *D. Pileolus*, Hicks, occurs in the Menevian group of South Wales, and *D. Crassa*, Hall, in Llandeilo rocks, while we have six species in the Caradoc. *D. rugata*, Sow., is in Upper Llandovery, and this and two other species are in Wenlock rocks. Three species also appear in the Ludlow group, but the Lower and Middle Devonians do not appear to contain Discinæ. In the Upper Devonians we have *D. nitida*, Phill., and in Carboniferous Limestone the same species with *D. Davreuxiana*, De Kon., *D. nitida* ranges up into the Permian.

The Rhætic series of deposits yield a species of Discina, *D. Townshendi*, Forbes, and several species have been described from Liassic and Lower Oolitic strata. In the Upper Oolites, we find two or three species, and in the L. Greensand the *D. lævigata*, Desh. The recent species, *D. lamellosa*, Brod., was found fossil by Mr. S. V. Wood in the Coralline Crag of Sutton, thus a species is given to us from the British Tertiaries.

Recent Discinæ inhabit the waters of the East Indies, the West Coast of Africa, and the West Coast of South America.

EICHWALDIA, Billings, 1858. One species.

The *E. Capewellii*, Dav., has been called by different authors a

Terebratula, an Atrypa, a Rhynchonella, and a Porambonites, and it is now only with some degree of uncertainty referred to Billings' genus Eichwaldia.

E. Capewelli occurs in the Woolhope and Wenlock limestones, and is the only British species which has been assigned to the genus Eichwaldia.

KUTORGINA, Billings, 1861. One species.

This is another genus represented in the British area by only one species. Kutorgina is a genus of Lingulidæ, and our British species was named as an Obolella, the *O. Phillipsii*, Holl. This name must now be regarded as a synonym of the Canadian *Kutorgina Cingulata*, Bill., though the American specimens are much larger than the British.

K. cingulata was found in the Hollybush Sandstone of Malvern, which is considered the equivalent of the Middle Lingula Flags.

LEPTÆNA, Dalman, 1827. Sixteen species.

Leptæna is now much restricted, and comprises a much fewer number of species than would have been included in the genus by Dalman. It is still, however, an important section of the family Orthidæ. Leptæna is nearest allied to Strophomena, but differs from that genus chiefly in the character of the muscular impressions, which in Leptæna are large and elongated.

Leptæna commences with *L. sericea*, Sow., and *L. tenuicincta*, McCoy, in the Llandeilo rocks, has five species in the Caradocs, four in the Lower, and the same number in the Upper Llandovery, three in Wenlock, and one in Ludlow strata. The Devonians yield but three species, one *L. laticosta*, Conrad, appearing in the Lower Devonian, and two, *L. interstrialis*, Phill., and *L. nobilis*, McCoy, in the Middle Devonian. There are two doubtful occurrences in the Carboniferous Limestone, but the uppermost Palæozoic rocks appear to be quite devoid of representatives of the genus Leptæna. The researches of Mr. C. Moore have resulted in the discovery of several species of Leptæna in the Middle and Upper Lias of England.

The range of Leptæna therefore appears to be from the Llandeilo to the Upper Lias, and the range of Orthidæ is consequently extended into the Mesozoic rocks.

LINGULA, Bruguière, 1789. Thirty-eight species.

The important and well characterized genus Lingula, of which

Lingulella may be considered a sub-genus, is worthy of special attention, from the fact that Cuvier was induced to constitute the class Brachiopoda from the study of the anatomy of a Lingula. The ceratose character, and the tongue-like form of the shell, render this genus very distinctive, and one easily recognised, whether in the fossil or in the recent state.

The range of Lingula almost rivals that of Discina. Commencing in Primordial Silurian strata, Lingula (excluding Lingulella) passes up through all the great divisions of British strata, and is still a flourishing, living form of life, sixteen species of recent Lingulæ having been described as inhabiting the seas of the East Indies and the Pacific Ocean. *L. squamosa*, Holl, appears to be our earliest representative of the restricted genus Lingula. This species occurs in the Hollybush Sandstone of the Malverns or the Middle Division of the Lingula Flags. The name "Lingula Flags," was however given from the abundance in this formation of a species which is now placed in Lingulella, the *L. Davisii*, McCoy. In the black shales of the Malverns, the equivalent of the Upper Lingula Flags, another species of Lingula is found, *L. pygmæa*, Salter. From the Llandeilo rocks six species have been obtained, five from Caradoc, four from Upper Llandovery, three from Wenlock, and six from Ludlow rocks. It is doubtful whether *L. cornea*, Sow., of the Passage Beds, passes up into the Lower Devonians, but in the Upper Devonians we find *L. squamiformis*, Phill. A considerable increase of Lingulæ occurs in the Carboniferous Limestone, from which we derive six species, but in the Permian Magnesian Limestone we only obtain one species, *L. mytiloides*, Sow. Lingulæ are not numerous in our Secondary or Tertiary strata, not more than two species occurring in any one formation. *L. Davidsoni*, Oppel, and *L. metensis*, Terq., are in the Lower Lias, *L. Voltzii*, Terq., in the Middle, and *L. Longovicensis*, Terq., in the Upper Lias. *L. Beanii*, Phil. Mr. Tate considers to be restricted to the Inferior Oolite, and what has hitherto been called *L. Beanii* from the Lias, to be the *L. Voltzii* of Terquem. *L. lævis*, Bean, M. S. and *L. ovalis*, Sow., occur in the Oxford and Kimmeridge Clays, and *L. truncata*, Sow., and *L. sub-ovalis*, Dav., in the Lower and Upper Greensands, while *L. tennis*, Sow., is in Lower Eocene strata, and our latest Lingula, *L. Dumortieri*, Nyst, in the Older Pliocene.

LINGULELLA, Salter, 1866. Four species.

The separation of Lingulella from Lingula depends upon the existence in two or three species of a groove or canal for the passage of the pedicle. The muscular scars, too, in Lingulella, are, in some respects, similar to those in Obolus, but the internal characters have not yet been distinctly ascertained.

So far as has yet been with certainty discovered, Lingulella is our earliest genus, or sub-genus of Brachiopoda. Mr. Hicks found *Lingulella ferruginea*, Salt., so low down as the base of the Harlech Group of Sedgwick. This is in the Cambrian of the Survey,* and much below the base of the lowest of the Silurians of Murchison.

L. ferruginea is recurrent in the Menevian group, and in the overlying Lingula Flags we have *L. Davisii*, McCoy, which occurs also in the Tremadoc beds with *L. lœpis*, Salt. The *L. Davisii*, as has been before stated, gives name to the Lingula Flags, in which formation, in many localities, this small species is extremely abundant. *L. Lœpis* passes up, it is stated, into Llandeilo rocks, but we have not as yet conclusive evidence of this. Above the Llandeilo group, however, no species has hitherto been found, and we must therefore at present consider Lingulella to be restricted to the Cambrian and Lower Silurians.

MAGAS, Sowerby, 1818. One species.

This genus of the Terebratulidæ differs from the other members of that family in possessing a peculiar apophysary system, consisting chiefly of an elongated longitudinal septum so prominent as to extend from its own or dorsal valve to the opposite or ventral valve.

As Lingulella may be considered our earliest British Brachiopod so Magas may be called our latest, since this genus does not make its appearance until we reach the Chalk, all our other genera and sub-genera being represented in strata older than this, the uppermost division of our Cretaceous series.

Our one species of Magas *M. pumilus*, Sow., has been found in several localities, both in Norfolk and Sussex, in the Upper Chalk, and is abundant on the continent of Europe, in the same formation.

A recent Brachiopod, inhabiting the seas of New Zealand, has a similar apophysis to that of Magas, but externally the shell is dissimilar. Magas is, however, stated to be living in the seas of the Canary islands.

* Mr. Hicks has described in a paper read before the Geological Society, May 10th, 1871, a second species of Lingulella, from these Cambrian rocks, and has named it *Lingulella primæva*.

MEGERLIA, King, 1849. Three species.

Megerlia is distinctly separated from the other genera of the Terebratulidæ by the internal loop being trebly attached.

Until recently this genus was considered to be restricted to the Cretaceous System, but the placing of *Argiope Suessii*, Desh., and *Argiope Perieri*, Desh., in Megerlia, removes the commencement of the range of this genus to Liassic strata. Our old Megerlia, *M. lima*, Defrance, is the only other British species as yet known, and this occurs in the Gault, the Upper Greensand, and the Chalk.

MERISTA, Suess. Two species.

This genus of Spiriferidæ has a septum supported by arched plates which have been described as resembling a "shoe-lifter." Merista is closely allied to Atrypa.

A species which is with some doubt assigned to this genus, the *M. cymbula*, of Davidson, occurs in the Caradoc of Cerrig-y-druidion, but it is not until we reach the Middle Devonian that we find a good type of Merista. This is *M. plebeia*, Sow., which is very abundant in the Middle Devonian limestones of Devonshire. *M. plebeia* is also stated to occur in the Carboniferous Limestone of Ireland.

MERISTELLA, Hall, 1860. Nine species.

Several British species which would otherwise be placed in Merista are without the peculiar arched plate in the ventral valve, distinguishing that genus. For these the genus Meristella was constituted, and some forms long known as Atrypas were accordingly placed in it.

The range of Meristella appears to commence in the Lower Llandovery, continues through the Upper Llandovery, the Wenlock, and the Ludlow, above which group no species of this genus has hitherto been found. The greatest specific development is in the Wenlock group, from which we derive five species, amongst which are the well-known *Meristella tumida*, Dal., and *Meristella didyma*, Dal. These two species pass up into the Ludlow rocks.

NUCLEOSPIRA, Hall, 1859. One species.

Nucleospira has been constituted to receive certain species which appear to combine the characters of Orthis and Spirifera, but on account of the existence of spiral appendages in these species the genus is placed among the Spiriferidæ.

Though the American Silurians have furnished several species of Nucleospira, British strata have hitherto yielded only one, the *N. pisum*, Sow. This small species has occasioned much discussion, as to its proper generic position, it having been by different authors assigned to no less than six genera. *N. pisum* occurs in several localities in England, and in the Pentland Hills, in Wenlock Limestone and shale. It has a wide geographical distribution, the species being found in Gothland and America.

OBOLELLA, Billings, 1861. Four species.

This genus differs from Obolus, chiefly in the arrangement of the muscular impressions. So far as we yet know it is confined to Lower Silurian rocks.

Obolella may perhaps claim, with justice, an antiquity nearly equal to that of Lingulella, since rocks of Cambrian age have rewarded the labours of Mr. Hicks by yielding to the hammer of that gentleman what is considered to be *Obolella sagittalis*, Salt.

O. sagittalis is not uncommon in the Menevian rocks of South Wales, together with *O. maculata*, Hicks. One species, *O. Salteri*, Holl, occurs in rocks of Llandeilo age, above which the occurrence of this genus has not been recorded.

OBOLUS, Eichwald, 1829. Two species.

In Obolus, as in the typical genus of the family, Lingulidæ, the passage for the peduncle is between the two valves, which, resembling those of Lingula, are hingeless. Obolus is orbicular in shape, and the shell is described as calcareo-corneous.

Of the two species of Obolus *O. plumbeus*, Salt., and *O. Davidsoni*, Salt., which occur in British strata, the former is confined to Llandeilo rocks, while *O. Davidsoni* appears to be restricted to those of Wenlock age. One is thus characteristically Lower Silurian, and the other characteristically Upper Silurian. The typical form of *O. plumbeus* occurs in the Upper Arenig rocks of North Wales, but a variety *plicata*, the *Obolella plicata* of Mr. Hicks, is found in the Lower Arenig of South Wales. Two varieties of *O. Davidsoni*, *transversus* and *Woodwardi*, are found with the typical form of the species in the Wenlocks of Siluria.

ORBICULOIDEA, D'Orbigny, 1847. Two species.

This genus or sub-genus is very similar to Discina, but it differs from that genus in the character of the foramen. Professor Morris considers that Orbiculoidea is identical with the

Schizotreta of Kutorga, and Mr. Davidson endorses the determination of the learned Professor.

Of Orbiculoidea, two species are described as occurring in our Wenlock limestones and shales, but of these one, *O. Beckettiana*, Dav. (a very large species), is so doubtful that Mr. Davidson is not quite sure that it is a Brachiopod. We can, therefore, only safely say that one species of Orbiculoidea occurs in British strata. This is the *O. Forbesii*, Dav., of the Woolhope and Wenlock Limestones.

ORTHIS, Dalman, 1827. Fifty-six species.

Orthis, the typical genus of the important family of Orthidæ, is largely developed in the older rocks. The hinge-line, straight, as in all the Orthidæ, is not so long as the width of the shell. There is a fissured area on both the ventral and the dorsal valve, and the shell structure is punctate.

Orthis is an essentially Palæozoic genus, ranging from the middle beds of the Menevian group to the Carboniferous Limestone, *O. Hicksii*, Salt., from the former of the rocks above-named, and *O. lenticularis*, Wahl., from the Upper Lingula Flags, are our earliest species. Ten species occur in beds of Llandeilo age, and no less than thirty-five species have been taken from the Caradoc, in which formation Orthis seems to have attained its maximum development. In Lower Llandovery strata we find eighteen species, in Upper Llandovery eleven, in Wenlock fifteen, and in Ludlow six. The Devonians have furnished six species, of which four are in the Lower, five in the Middle, and two in the Upper Division. Though ten or eleven species have been stated to occur in Carboniferous Limestone, we cannot safely locate more than four species in that formation. The occurrence of Orthis above Carboniferous strata has not been recorded, nor do we find any representative of the family, except one species of Streptorhynchus in the uppermost Palæozoic rocks.

ORTHISINA, D'Orbigny, 1849. One species.

A convex pseudo-deltidium, covering the fissure in the double area, is the chief external differentiation of Orthisina, which was separated from Orthis by D'Orbigny in 1849, though Pander, in 1830, had proposed the name Pronites for this genus.

Only one species, the *Pronites adscendens*, of Pander, appears in British rocks, the *Orthisina Scotica* of M'Coy having been determined to be an Orthis proper, and a variety of *Orthis caligramma*, Dal. *Orthisina adscendens* appears to be confined in the British area to the Lower Llandovery rocks of North Wales, but in Russia it is a very abundant and widely-spread species.

PENTAMERUS, Sowerby, 1813. Nine species.

Pentamerus was so named to indicate that the shell is made up of five distinct portions. This genus differs from the other members of the family Rhynchonellidæ in having a triangular foramen, and in the dorsal valve possessing two longitudinal septa, which approach the edges of a trough-like process in the ventral valve.

Pentameri are found in Lower and Upper Llandovery rocks in Wenlock, in Ludlow, and in Middle Devonian rocks. Nine species occur in the British area, but some of these are abundant. *P. Knightii*, Sow., the type of the genus, is a well-known and common fossil in the Aymestry Limestone. The species also occurs in the Wenlock Limestone, and is found both in England and Ireland, though not in Scotland. It also occurs in Russia and Bohemia. In America the genus Pentamerus gives name to two members of the Helderberg group, which are called the Upper and Lower Pentamerus Limestones.

PORAMBONITES, Pander, 1830. One species.

The distinctive characters of this genus have not yet been very clearly made out, though sufficient is known to justify its being placed among the Rhynchonellidæ. Although, as in all the other members of this family, the shell structure is impunctate, the surface of Porambonites is minutely and beautifully pitted.

A species from the Lower Silurians of Ireland, described by M'Coy as *Atrypa filosa*, has been determined by Mr. Davidson to be a variety of the *Porambonites intercedens* of Pander. We thus find this genus, so characteristic of the Lower Silurians of Northern Russia, to be represented in the British Islands. Hitherto, however, no examples of the genus have been with certainty found in either England, Scotland, or Wales, and the *P. intercedens*, var. *filosa*, of the Carodocs of Waterford is the solitary representative of the genus in the British area.

PRODUCTUS, Sowerby, 1814. Forty-eight species.

This concave, auriculate, spiniferous, and edentulous genus is the principal member of an important and essentially Palæozoic family the Productidæ.

specific distribution of Productus is very remarkable, since, the species are very numerous, they are almost confined to rboniferous Limestone. The earliest occurrence of Productus ish strata is in the Middle Devonians of South Devon, in rocks, *P. subaculeatus*, Murch., is abundantly found. This is recurrent in the Upper Devonians, from which five species een derived. From the Carboniferous Limestone a large r of species, or so-called species, have been described. Many e have upon examination been found to be wanting in suffi- distinctive characters to warrant their being considered new

" Morris' Catalogue," edition of 1854, 46 species of Pro- from the Carboniferous Limestone were retained, but in Mr. Davidson, after a minutely critical examination, consi- hat the number ought to be reduced to 28. Subsequently, r, several species from the Lower Scar Limestone of Settle, rkshire, were added, and these, with two or three others, the total to about forty species of Productus, occurring in rboniferous or Mountain Limestone of the British Islands. ' barren formation," the Millstone Grit, has yielded to the ring labours of Mr. D. C. Davies, of Oswestry, three or four of Productus, and the Permian Magnesian Limestone gives *horridus*, Sow., and *P. latirostratus*, Howse.

Rensselæria, Hall, 1859. One species.

sselæria is an ovoid form of Terebratula, with an elongated nd nearly allied to the Meganteris of Suess.

ecies from the Devonian Limestone of Haggington Hill, fracombe, is considered to be the Rhenish *R. stringiceps* of r. This species is stated by Mr. Etheridge to occur also in ddle Devonian rocks of Torquay. It is, however, the only of Rensselæria recorded as occuring in British strata.

Retzia, King, 1850. Six species.

is a terebratuloid genus of the family Spiriferidæ. The tructure is punctate, the foramen terminal and the internal processes are directed outwards.

range extends from the Wenlock rocks to the Carboniferous tone, and the genus is therefore Palæozoic. Of the six described as occuring in British rocks, two are in Wenlock, one in Middle Devonian, and three in the Carboniferous Limestone. One of the Wenlock species, *R. Salteri*, Dav., has two well marked varieties, *Baylei* and *Bouchardii*, and it is stated that the former of these occurs in rocks of Ludlow age.

RHYNCHONELLA, Fischer, 1809. One hundred and one species.

Rhynchonella is a very important genus, important not only on account of the number of its specific forms and of the extent of its range in the stratified rocks, but also on account of the great abundance of Rhynchonellæ in many rocks, and of the apparent restriction of some of the well-known and easily recognisable forms of the genus to certain formations which these species thereby characterise.

Though Rhynchonella is the type genus of one family, and Terebratula the type genus of another, and they are, therefore, widely separated, yet these two genera come so frequently under the notice of young geologists, that it may be useful here to briefly point out the external characters by which each genus may be known.

The most easily observed difference is in the *position of the foramen.* In Rhynchonella the termination of the beak is acute, and covers the foramen, which is, therefore, situated *under* and *inside* the beak. In Terebratula, on the contrary, the foramen is *terminal,* and formed by the *truncation* of the beak, which is consequently not acute. The shell structure of Rhynchonella is *impunctate* and fibrous, while that of Terebratula is *punctate.* These differences, will, moreover, separate all the Rhynchonellidæ from all the Terebratulidæ.

The range of Rhynchonella is from the Llandeilo rocks to our most recently formed deposits, these latter containing a species *R. psittacea*, Lam., which is still living off the coast of Scotland and in the northern seas. Our oldest known form of Rhynchonella is the *R. Salteri*, Dav., which has been found in strata of Llandeilo age. This species occurs more abundantly in Caradoc rocks, from which five other species have been obtained. Three species occur in the Lower Llandovery, and five in the Upper Llandovery, while nine are given to us by Wenlock and six by Ludlow rocks.

The Devonians yield fifteen species, of which four are in the Middle, five in the Lower, and six in the Upper division. Fourteen occur in the Carboniferous Limestone, and one of these (*R. pleurodon*, Phill.) is stated to range into the Millstone Grit ; but the uppermost Palæozoic rocks have not hitherto furnished us with a single representative of Rhynchonella proper, though Camarophoria, which by some would be considered a sub-genus of Rhynchonella, has three species in the Permian Magnesian Limestone. It is, however, in the lower Jurassic rocks that we find the maximum specific development of Rhynchonella, since we have obtained from the Middle Lias fourteen species, and from the Inferior Oolite twenty-five, the greatest number of species hitherto given to us by any single formation.

Not many species occur in the Middle and Upper Oolites, but in Cretaceous rocks they are again numerous, especially in the Upper Cretaceous. Tertiary deposits yield but one species (the before-mentioned *R. psittacea*), which occurs in the Norwich Crag, and in the newer Tertiary deposits of Scotland. This species now lives in from thirty to one hundred fathoms water in the Northern Seas, and *R. nigricans* is found in nineteen fathoms water off New Zealand.

SIPHONOTRETA, De Verneuil, 1845. Two species.

A straight, thick, conical beak, perforated by a tubular foramen, opening at the back of the beak; tubular spines, concentric lines of growth, and a conspicuously punctated shell structure, distinguish this interesting member of the family Discinidæ.

The genus is essentially Palæozoic, and in the British area it has not been found, except in rocks of Llandeilo and Wenlock age. To our President, Professor Morris, we are indebted for the recognition and description of the first species of the genus discovered in British strata. In 1849 was published, in "The Annals and Magazine of Natural History," his description and figures of *S. Anglica*, Morris, from the Wenlocks of Dudley. This species has since been found in the neighbourhood of Coniston, and a second species (*S. micula*, McCoy) was described by Professor McCoy in 1851, from Llandeilo rocks. *S. micula* is found in Wales, Scotland, and Ireland.

SPIRIFERA, Sowerby, 1815. Forty-eight species.

The typical genus is distinguished from the other members of the great family Spiriferidæ by a long, straight hinge, angular foramen, and impunctate shell structure.

Spirifer proper seems in the British area to be confined to

Palæozoic strata, from which forty-eight well-marked species have been derived. The number of British Spirifers was at one time thought to be much greater, but the careful investigations of Mr. Davidson have shown that many of the so-called species had no claim to be considered distinct specific forms.

We cannot place Spirifera with certainty in the Lower Silurians, but in the lowermost member of the Upper Silurians, the Upper Llandovery, we find *S. crispa*, His., and *S. elevata*, Dalm.; while in the Wenlock rocks above five species occur, and three of these pass up into the Ludlow group. Twenty-one species are Devonian, and twenty-eight (the maximum number) Carboniferous. In the Permian Magnesian Limestone, *S. Urii*, Flem., and *S. Alata*, Schl., occur. The Jurassic "Spirifers" have been, on account of their punctate shell structure, placed in the genus Spiriferina, thus the range of Spirifer in British strata extends from the Upper Llandovery to the Permian, with the maximum development in the Carboniferous Limestone.

SPIRIFERINA, D'Orbigny, 1847. Thirteen species.

Spiriferina is separated from Spirifera proper by the punctated character of the shell structure. A mesial septum, wanting in true Spiriferæ, is found in Spiriferina.

The range of Spiriferina, so far as yet known, is in the British area from the Lower Devonians to the Inferior Oolite, *S. cristata*, Schl., occurring in the former, and *S. Oolitica*, Moore, in the latter formation. For the discovery of *S. Oolitica*, as for that of several other species of this genus in the Lias, we are indebted to Mr. Charles Moore, who has thus extended the known range of the punctated Spirifers and of the family Spiriferidæ.

It is not improbable that further research will show that the range of Spiriferina commences earlier than is stated above. The *S. cristata* bears a striking resemblance to the Silurian *Anomia crispa*, of Linnæus, and Mr. Davidson seemed inclined to consider them the same species, though he has subsequently adopted Lindström's view that the *Anomia crispa* is the *Spirifera sulcata* of Hisinger.

STREPTORHYNCHUS, King, 1850. Seven species.

Although closely allied to Orthisina, Streptorhynchus differs from that genus in being without any appearance of a foramen, and in having the beak bent or twisted, from which latter character the name Streptorhynchus was given by Professor King.

This genus, or sub-genus, is Palæozoic in range, but has a wide geographical distribution, species being found in Europe, Asia, America, and Australia. In the British area we have four species in Lower Devonian rocks, two in Middle, and three in Upper Devonian. In the Carboniferous Limestone, one of the Devonian species, *S. crenistria*, is recurrent, and assumes so many modifications of form that four *varieties* have been described as so many separate species. In the Permian Magnesian Limestone of the north-east of England, we find *S. pelargonatus*, Schl., which we may take as a type of the genus.

STRICKLANDINIA, Billings, 1859. Two species.

This genus has been separated from Pentamerus chiefly on account of the non-development of the mesial septa, which form so marked a feature in the internal structure of typical Pentameri. Stricklandinia also differs from Pentamerus, in being sub-equivalve and never globose.

Stricklandinia lens, Sow., and *S. lirata*, Sow., are the only species of this genus found in the British area. Both occur in the Lower and Upper Llandovery rocks, and *S. lirata* passes up into Wenlock strata.

STRINGOCEPHALUS, Defrance, 1827. One species.

The distinctive characters of this genus are so many and so important, that they seem to justify our placing Stringocephalus in a family or sub-family by itself, as was at one time done. It agrees, however, with the Terebratulidæ, in possessing an internal loop, and in having a punctated shell structure, and it is now placed in that family. Stringocephalus has a large mesial septum in the ventral valve, a very strong and long cardinal process proceeding from the dorsal valve, and bifurcating to clasp the ventral septum, and a large sub-marginal loop, furnished with lamellæ branching from the inner edge.

Only one species of this genus has been discovered in the British Isles. This is the *Stringocephalus Burtini*, Defr., a characteristic species of the Middle Devonian of both England and Germany.

STROPHALOSIA, King, 1844. Four species.

Strophalosia has great affinities with Productus, and Mr. Davidson and M. De Koninck were for some time inclined to dispute its claim to be considered a separate genus. This claim has, however, now been admitted, principally on account of the articulation of the valves, and four species, and three well-marked varieties, chiefly from the Permians of Durham, have been assigned to Strophalosa. *S. productoides*, Murch., appears in the Devonian rocks, in the Middle Devonians, according to Mr. Pengelly, and passes up into Carboniferous strata.

STROPHOMENA (Rafinesque), De Blainville, 1825.
Twenty-seven species.

The Palæozoic genus, Strophomena, is an important member of the family Orthidæ, from the typical genus of which family it differs in being concavo-convex, and in having the fissure in the ventral valve covered by a pseudo-deltidium. Strophomena is very nearly related to Leptæna, but as has been previously stated, the latter genus is characterized by thickened, elongated muscular impressions in the dorsal valve. The range of Strophomena, like that of Orthis, is confined to Palæozoic strata, and the genus may almost be said to be characteristically Silurian, since only one of the many species of Strophomena occurs in strata above the Ludlow group. This species, however, *S. rhomboidalis*, Wahl., with its variety, *analoga*, Phill., passes up through the Devonians and into Carboniferous rocks. Our earliest species are *S. corrugatella*, Dav., and *S. Compressa*, Sow., var. *Llandeiloensis*, Dav., which appear in Llandeilo strata. Twelve species occur in Caradoc rocks, three in Lower Llandovery, six in Upper Llandovery; fourteen, the maximum number in Wenlock, and four in Ludlow rocks.

SUESSIA, Deslongchamps, 1854. One species.

Suessia has a great similarity to Spiriferina, but is separated from that genus by a fibrous shell structure, as well as by certain minute and complex internal arrangements.

Suessia supplies but one species to our British fauna. This, the *Suessia imbricata*, Deslong., was discovered in the Middle Lias of Whatley, near Frome, by Mr. Charles Moore.

SYRINGOTHYRIS, Winchell, 1863. One species.

This is another genus or sub-genus closely allied to Spirifera and Spiriferina. From the former Syringothyris differs in having a punctate shell structure, and from the latter in possessing in the interior a transverse plate, by which the vertical dental lamellæ are connected, and thus a fissured tube is formed.

Of Syringothyris, we have but one species, *S. distans* (the *Spirifera distans* of Sowerby), which occurs in the Carboniferous Limestone of Ireland, and in the same formation at Bolland in Yorkshire.

TEREBRATELLA, D'Orbigny, 1847. Nine species.

A loop in the dorsal valve, doubly attached, first to the hinge-plate, and secondly by transverse processes to a mesial septum, characterises this genus of the family Terebratulidæ.

Terebratella ranges from the Lias to the Chalk in British strata, and is represented by nearly thirty species in the present seas of the globe. It flourishes in 90 fathoms water, and is found in both northern and southern seas.

The *T. Liasina*, Deslong., in the Middle Lias, the *T. furcata*, Sow., and the *T. Buckmanii*, Woodw., in the Great Oolite, are the only Jurassic forms as yet discovered in the British area. In the Lower Greensand, however, we find five species, in the Upper Greensand two, and in the Chalk two also; but the Tertiaries have not hitherto yielded any species of Terebratella.

TEREBRATULA, Llhwyd, 1699. Sixty-three species.

This important and well-known genus is distinguished from the other genera of the great family, of which Terebratula is the head, by a *short* and *simple* loop in the dorsal valve. In common with the other members of the family, Terebratula has a punctated shell structure, and a foraminated ventral valve.

Terebratula ranges in British strata from the Devonians to the Older Pliocene, and attains its maximum development in the Inferior Oolite. The genus has also living rspresentatives which inhabit the Mediterranean Sea, Vigo Bay, and the seas around the Falkland Islands. Our earliest forms of Terebratula are *T. sacculus*, Mart., *T. juvenis*, Sow., and *T. Newtoniensis*, Dav., all from the Middle Devonians of South Devon. One of these species, *T. sacculus*, passes up into Upper Devonian strata, in which we find also a species which has been considered to be the Permian *T. elongata*, Schl. The Carboniferous and Permian rocks do not yield more than four or five species, with, however, two or three well marked varieties of one, the *T. hastata*, Sow. In Lower Jurassic strata we observe a great development of Terebratula, no less than about thirty species occurring in these rocks, of which number the

Inferior Oolite contains twenty. No occurrence of Terebratula in strata between the Coralline Oolite and the Lower Greensand has been recorded, but in the latter formation fourteen species occur. There is also a considerable development of Terebratula in Upper Cretaceous strata, eleven or twelve species being found in the Upper Greensand and the Chalk. Tertiary deposits yield but two species of Terebratula, *T. bisinuata*, Lam., and *T. grandis*, Blum. The former is from the Bracklesham and Barton beds of the Middle Eocene, and the latter, *T. grandis*, is common to the Red and Coralline crags of East Anglia.

TEREBRATULINA, D'Orbigny, 1867. Seven species.

. Though Terebratulina is usually considered a sub-genus of Terebratula, the annular apophysary skeleton and the auriculate character of the dorsal valve appear to constitute a generic differentiation.

The range of Terebratulina is like that of Terebratella, and there is also a similarity in the distribution of the species of these two members of the Terebratulidæ. The Jurassic forms *T. Deslongchampsii*, Dav., and *T. radiata*, Moore, are confined to the Middle Lias and the Lower Oolites, and the maximum development is found in Cretaceous strata, while the Lower and Middle Eocenes yield one species and the Crag one species. The Crag species is the *T. caput-serpentis* of Linnæus, which inhabits our own seas. *T. caput-serpentis* is not unfrequently dredged in from ten to fifty fathoms water among the Hebrides.

TEREBRIROSTRA, D'Orbigny, 1847. One species.

Terebrirostra is a very remarkable form of Brachiopod, and yet much doubt has been expressed as to whether it is entitled to generic or even sub-generic rank. This doubt arises from the character of the apophysis not having been distinctly ascertained, though there is reason to believe that the loop is doubly attached. The great elongation of the beak distinguishes this from all other members of the Terebratulidæ, and their rarity and elegance cause specimens of our one species of Terebrirostra to be much prized by their possessors. This species is the *T. lyra*, Sow. It occurs in the Upper Greensand of Wiltshire, and in the lowermost member of the chalk series, the "Chloritic Marl," at Chardstock, in Dorsetshire.

THECIDIUM, Defrance, 1828. Fifteen species.

This well-marked genus is allied to the Terebratulidæ by an internal loop, but the absence of a foramen, the thickened shell and granulated margin, as well as general character and habit, warrant the placing of Thecidium in a separate family.

The range of this genus in British strata, as far as yet known, is from the Lower Lias to the Upper Chalk, and the greatest specific development is in the Lower Jurassic formations. Though no representative of Thecidium has yet been found in our Tertiary strata, the *T. Mediterraneum* flourishes in the sea from which its specific name is derived. To the labours of Mr. Charles Moore we are indebted for most of our Jurassic forms, and to Professor Morris for the description of our only Cretaceous species, the *T. Wetherelli*, Morris, of the Upper Chalk of Gravesend, and the Chalk of Wiltshire.

TRIGONOSEMUS, Kœnig, 1825. Two species.

Trigonosemus is closely allied to Terebratella, the internal loop being doubly attached, and incurved like the apophysary system of that genus. A lengthened incurved beak, with a large area and a very prominent cardinal process, are, however, considered to be sufficiently important characters to justify the separation of Trigonosemus from Terebratella as a sub-genus, though scarcely important enough to give it generic rank.

Two species only of Trigonosemus have hitherto been found in the British area, and these are confined to Upper Cretaceous strata. *T. incertus*, Dav., was taken from the Chalk with green grains of Chard, by Mr. Moore, and *T. elegans*, Kœnig, occurs in the Upper Chalk of Norfolk, and the Chalk Detritus of Charing, Kent. The latter is a characteristic species of the Chalk of France and Belgium.

TRIPLESIA, Hall, 1859. Three species.

The internal characters of this new genus have not yet been determined, and Triplesia can only therefore be provisionally placed in Rhynchonellidæ. In Triplesia the hinge line is rectilinear or sub-rectilinear, and the foramen triangular. Concentric as well as radiating striæ on the external surface of the valves are to be observed.

Three species of Triplesia have been described as occurring in British strata, but about two of these some doubt remains. *T. Grayiæ*, Dav., occurs in Llandeilo and Caradoc rocks, and *T.? Maccoyana*, Dav., with *T.? monilifera*, McCoy, in Caradoc only.

UNCITES, Defrance, 1848. One species.

Uncites has affinities both with Pentamerus and Retzia, but the internal spiral processes separate this genus from the Rhynchonellidæ, and place it in Spiriferidæ, while the impunctate character of the shell structure and the absence of the hinge-area differentiate Uncites from Retzia.

Uncites was, until 1863, unknown in British strata; but in that year the Eifel species, *U. gryphus*, Schl., was detected by Mr. Davidson amongst some fossils from the Middle Devonians of the neighbourhood of Totness; and Mr. Vicary, of Exeter, has since found this species in the same formation, near Newton Abbot. No other representation of Uncites has hitherto been obtained from British rocks.

WALDHEIMIA, King, 1849. Twenty-nine species.

The genus or sub-genus Waldheimia was constituted by Professor King to contain those species of Terebratula, which were furnished with *long* loops, or loops extending to near the exterior margin of the valves, Terebratula being thus restricted to comprise only species having *short* loops or loops of about one-third the length of the shell. The careful examination to which the Terebratululidæ have of late years been subjected, has resulted in giving to this genus several species that have long been known under the generic designation of Terebratula.

Waldheimia ranges, so far as has yet been ascertained, from the Lower Lias to Upper Cretaceous strata, and has a great development in the Middle Lias, the Lower Oolites, and the Lower Greensand.

From the bottom of the river Cam at Heremere, near Upware, a species of Waldheimia was brought up and named by Mr. Ray Lankester *W. rex*. It could not be ascertained from what formation the specimens were derived; but there was some reason for the belief that the matrix was of Portlandian age. This conjecture was strengthened by the subsequent finding of the same species in drift blocks at Thorpe, Suffolk, of what appeared to be Portland Oolite. Should the *Waldheimia rex* be from Portland strata it will be the first and only species of Brachiopoda derived from our Portlandian rocks; but from the peculiar circumstances under which the *W. rex* has hitherto been found, we can do no more at present than record a very doubtful occurrence of one species in the Portland Oolite.

Waldheimia is another Mesozoic genus which, although not appearing in our Tertiary deposits, is a still living form. The *W. Australis*, from the coast of Australia, is a well-known shell, and eight other recent species have been described.

ZELLANIA, Moore, 1854. Six species.

Some small Orthiform Brachiopods, with dorsal valves, similar in their interior to Thecidium, but generically unlike any known forms, were found by Mr. C. Moore in the Inferior Oolite of Dundry and in the Upper Lias of Ilminster. The new genus Zellania was accordingly founded by Mr. Moore for their reception. The author of the genus has since added to the number of species, and the range of Zellania is found to extend from the Lower Lias to the Coralline Oolite.

DISTRIBUTION OF GENERA.

The subjoined summary may be found useful :—

Number of Genera and Subgenera	53
Genera in Palæozoic strata	42
Genera in Mesozoic strata	18
Genera in Cainozoic strata	6
Genera ranging from Palæozoic to Recent	5
Genera ranging from Palæozoic to Cainozoic	4
Genera ranging from Palæozoic to Mesozoic	7
Genera ranging from Mesozoic to Recent...	6
Genera ranging from Mesozoic to Cainozoic	2
Genera confined to Palæozoic strata	35
Genera confined to Mesozoic strata...	9
Genera confined to Cainozoic strata	none.

Genera characteristic of single formations or minor groups of strata, 15, of which the following are the names, with the names of the formations to which they appear to be respectively restricted :—

Acrotreta	Llandeilo.
Calceola	Middle Devonian.
Davidsonia	Middle Devonian.
Eichwaldia	Wenlock.
Kutorgina	Primordial Silurian.
Magas	Chalk.
Nucleospira	Wenlock.
Orbiculoidea	Wenlock.
Orthisina	Lower Llandovery.
Porambonites	Caradoc.
Rensselæria...	Middle Devonian.
Stringocephalus	Middle Devonian.
Suessia	Middle Lias.
Syringothyris	Carboniferous Limestone.
Uncites	Middle Devonian.

TABLE I. *(continued).—Showing the Stratigraphical Range of each Genus and Species of British Fossil Brachiopoda.*

Genera and Species.	PALÆOZOIC.															MESOZOIC.																			CAINOZOIC.						
	CAMB.	SILURIAN. (Of Murchison.)							DEVONIAN.			CARBONIFEROUS.			PER.	TRIASSIC.			JURASSIC.											CRETACEOUS.					TERTIARY.						
	Cambrian. 1	Primordial Silurian. 2	Llandeilo. 3	Caradoc. 4	Lower Llandovery. 5	Upper Llandovery. 6	Wenlock. 7	Ludlow. 8	Lower Devonian. 9	Middle Devonian. 10	Upper Devonian. 11	Carb. Limestone. 12	Millstone Grit. 13	Coal Measures. 14	Permian. 15	Bunter. 16	Keuper. 17	Rhaetic. 18	Lower Lias. 19	Middle Lias. 20	Upper Lias. 21	Inferior Oolite. 22	Great Oolite. 23	Crb. For. Mar. & Br. Cl. 24	Oxford Clay. 25	Coralline Oolite. 26	Kimmeridge Clay. 27	Portland. 28	Purbeck. 29	Wealden. 30	Lower Greensand. 31	Gault. 32	Upper Greensand. 33	Chalk. 34	Lower Eocene. 35	Middle Eocene. 36	Upper Eocene. 37	Miocene. 38	Older Pliocene. 39	Newer Pliocene. 40	Recent.
ORTHIS *(continued).*																																									
O. fallax, *Salt.*	...	...	...	*	*																																				
O. flabellulum, *Sow.*	...	...	...	*																																					
O. Girvaniensis, *Dav.*	...	...	...	*																																					
O. Hirnantensis, *M'Coy.*	...	...	...	*																																					
O. hybrida, *Sow.*	...	...	...	*	*	*	*	*																																	
O. intercostata, *Port.*	...	...	...	*																																					
O. Lewisii, *Dav.*	...	...	...	...	...	...	*																																		
var. Hughesii, *Dav.*	...	...	...	*																																					
O. patera, *Salt.*	...	...	...	*																																					
O. plicata, *Sow.*	...	...	...	*																																					
O. porcata, *M'Coy*	...	...	...	*																																					
O. protensa, *Sow.*	...	...	...	?	*	*																																			
O. sagittifera, *M'Coy*	...	...	...	*	*																																				
O. Salteri, *Dav.*	...	...	...	*																																					
O. sarmentosa, *M'Coy*	...	...	...	*																																					
O. simplex, *M'Coy*	...	...	...	*																																					
O. Sowerbyana, *Dav.*	...	...	...	*	*																																				
O. tricenaria, *Conrad.*	...	...	...	*																																					
O. unguis, *Sow.*	...	...	...	*																																					
O. vespertilio, *Sow.*	...	...	...	*	*																																				
O. polygramma, *Sow.*																																									
var. Pentlandica, *Dav.*	...	...	...	...	?	?	*																																		

O. æquivalvis, *Dav.* ...	...	...	...	...	...	...	...	*							
O. basalis, *Dalm.*? ...	...	...	...	...	...	...	...	*							
O. crassa, *Lind.*	...	...	...	...	...	...	...	*	*						
O. Edgelliana, *Salt.* ...	...	...	...	...	...	...	...	*							
O. rustica, *Sow.*	...	...	...	...	...	...	...	*							
var. rigida, *Dav.* ...	...	...	...	...	...	...	...	*							
var. Walsalliensis, *Dav.*	...	...	...	...	...	...	...	*							
O. canaliculata, *Lind.* ...	...	...	...	...	...	...	...	...	*						
O. lunata, *Sow.*	...	...	...	...	...	...	...	...	*						
O. arcuata, *Phill.*	...	...	...	...	...	...	...	...	...	*	*				
O. granulosa, *Phill.* ...	...	...	...	...	...	...	...	...	...	*	*				
O. hipparionyx, *Van.* ...	...	...	...	...	...	...	...	...	...	*	*				
O. Michelini, *L'Ev.* ...	...	...	...	...	...	...	...	...	...	*	...	...	*		
O. striatula, *Schloth.* ...	...	...	...	...	...	...	...	...	...	?	*	*	?		
O. interlineata, *Sow.* ...	...	...	...	...	...	...	...	...	...	...	*	*	?		
O. antiquata, *Phill.* ...	...	...	...	...	...	...	...	...	...	...	...	...	*		
O. Keyserlingiana, *De Kon.*	...	...	...	...	...	...	...	...	...	...	...	...	*		
O. **resupinata**, *Martin.* ...	...	...	...	...	...	...	...	...	...	...	...	...	*	*	
LINGULA (*Lingulidæ*).															
L. pygmæa, *Salt.*	...	...	*												
L. squamosa, *Holl.* ...	...	...	*												
L. curta, *Conrad.*	...	...	...	*											
L. obtusa, *Hall.*	...	...	...	*											
L. petalon, *Hicks.*	...	...	...	*											
L. Ramsayi, *Salt.*	...	...	...	*											
L. granulata, *Phill.* ...	...	...	...	*	*										
L. attenuata, *Sow.*	...	...	...	*	?										
L. brevis, *Port.*	...	...	...	...	*										
L. longissima, *Pand.* ...	...	...	...	...	*										
L. ovata, *M'Coy.*	...	...	...	...	*										
L. tenuigranulata, *M'Coy.*	...	...	...	...	*										
L. Bechei, *Salt.*	...	...	...	...	...	...	*								
L. crumena, *Phill.* ...	...	...	...	...	...	...	*								
L. parallela, *Phill.*	...	...	...	...	...	...	*								
L. Symondsii, *Salt.* ...	...	...	...	...	...	...	*	*	*						
L. Lewisii, *Sow.*	...	...	...	...	...	...	...	*	*						
L. **striata**, *Sow.*	...	...	...	...	...	...	...	*	*						
L. **lata**, *Sow.*	...	...	...	...	...	...	...	...	*						
L. **minima**, *Sow.*	...	...	...	...	...	...	...	...	*						
L. **cornea**, *Sow.*	...	...	...	...	...	...	...	...	*	*					

TABLE I. (*continued*).—*Showing the Stratigraphical Range of each Genus and Species of British Fossil Brachiopoda.*

GENERA and SPECIES.	PALÆOZOIC.															MESOZOIC.																			CAINOZOIC.						
	CAMB.	SILURIAN. (Of Murchison.)							DEVONIAN.			CARBONIFEROUS.			PER.	TRIASSIC.			JURASSIC.											CRETACEOUS.					TERTIARY.						
	1 Cambrian.	2 Primordial Silurian.	3 Llandeilo.	4 Caradoc.	5 Lower Llandovery.	6 Upper Llandovery.	7 Wenlock.	8 Ludlow.	9 Lower Devonian.	10 Middle Devonian.	11 Upper Devonian.	12 Carb. Limestone.	13 Millstone Grit.	14 Coal Measures.	15 Permian.	16 Bunter.	17 Keuper.	18 Rhætic.	19 Lower Lias.	20 Middle Lias.	21 Upper Lias.	22 Inferior Oolite.	23 Great Oolite.	24 Crb. For. Mar. & Br. Cl.	25 Oxford Clay.	26 Coralline Oolite.	27 Kimmeridge Clay.	28 Portland.	29 Purbeck.	30 Wealden.	31 Lower Greensand.	32 Gault.	33 Upper Greensand.	34 Chalk.	35 Lower Eocene.	36 Middle Eocene.	37 Upper Eocene.	38 Miocene.	39 Older Pliocene.	40 Newer Pliocene.	Recent.
LINGULA (*continued*).																																									
L. squamiformis, *Phill.*											*	*																													16 sps. Indian and Pacific Oceans.
L. Credneri, *Geinitz.*												*																													
L. latior, *M'Coy.*												*																													
L. Scotica, *Dav.*												*																													
L. Thompsoni, *Dav.*												*																													
L. mytiloides, *Sow.*												*	*		*																										
L. Davidsoni, *Oppel.*																			*																						
L. metensis, *Terq.*																			*																						
L. Voltzii, *Terq.*																				*																					
L. Longovicensis, *Terq.*																					*																				
L. Beanii, *Phill.*																						*																			
L. lævis, *Bean MS.*																									*																
L. ovalis, *Sow.*																									*		*														
L. truncata, *Sow.*																															*										
L. sub-ovalis, *Dav.*																																	*								
L. tenuis, *Sow.*																																			*						
L. Dumortieri, *Nyst.*																																							*		
KUTORGINA (*Lingulidæ*).																																									
K. cingulata, *Bill.*		*																																							
ACROTRETA (*Discinidæ*).																																									

T. Maccoyana, *Dav.* ...					*								
T. monilifera, *M'Coy* ...					*								
OBOLUS (*Lingulidæ*).													
O. plumbeus, *Salt.* ...				*									
var. plicata, *Hicks.* ...				*									
O. Davidsoni, *Salt.* ...								*					
var. transversus, *Salt.*								*					
var. Woodwardii, *Salt.*								*					
SIPHONOTRETA (*Discinidæ*).													
S. micula, *M'Coy*				*									
S. Anglica, *Morris*								*					
STROPHOMENA (*Orthidæ*).													
S. compressa, *Sow.*					*	?	*						?
var. Llandeiloensis, *Dav.*				*									
S. corrugatella, *Dav.* ...				*	*								
S. antiquata, *Sow.*					?	?	*	*					
S. deltoidea, *Conrad.* ...					*								
var. undata, *M'Coy* ...					*								
S. expansa, *Sow.*					*	*							
S. grandis, *Sow.*					*								
S. Holli, *Dav.*					*	?							
S. imbrex, Pand.													
var. semiglobosa, *Dav.*					?	?	?	*					
S. Jukesii, *Dav.*					*								
S. pecten, *Linn.*					?	?	*	*					
S. retroflexa, *Salt.*					*								
S. rhomboidalis, *Wilckens.*					*	*	*	*	*	*	*	*	*
var. analoga, *Phill.* ...										*	*	*	*
S. Siluriana, *Dav.*					?	*							
S. simulans, *M'Coy* ...					*		?						
S. ungula, *M'Coy.*					*								
S. arenacea, *Salt.*							*						
S. euglypha, *His.*							*	*	*				
S. funiculata, *M'Coy* ...							?	*					
S. applanata, *Salt.*								*					
S. Dayi, *Dav.*								*					
S. filosa, *Sow.*								*	*				
S. Fletcheri, *Dav.*								*					

TABLE I. *(continued).—Showing the Stratigraphical Range of each Genus and Species of British Fossil Brachiopoda.*

GENERA and SPECIES.	PALÆOZOIC.															MESOZOIC.																			CAINOZOIC.						
	CAMB.	SILURIAN. (Of Murchison.)							DEVONIAN.			CARBONIFEROUS.			PER.	TRIASSIC.			JURASSIC.											CRETACEOUS.					TERTIARY.						
	Cambrian.	Primordial Silurian.	Llandeilo.	Caradoc.	Lower Llandovery.	Upper Llandovery.	Wenlock.	Ludlow.	Lower Devonian.	Middle Devonian.	Upper Devonian.	Carb. Limestone.	Millstone Grit.	Coal Measures.	Permian.	Bunter.	Keuper.	Rhætic.	Lower Lias.	Middle Lias.	Upper Lias.	Inferior Oolite.	Great Oolite.	Crb., For. Mar. & Br. Cl.	Oxford Clay.	Coralline Oolite.	Kimmeridge Clay.	Portland.	Purbeck.	Wealden.	Lower Greensand.	Gault.	Upper Greensand	Chalk.	Lower Eocene.	Middle Eocene.	Upper Eocene.	Miocene.	Older Pliocene.	Newer Pliocene.	Recent.
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	
STROPHOMENA *(continued).*																																									
S. Hendersoni, *Dav.*							*																																		
S. Orbignyi, *Dav.*							*																																		
S. Walmstedti, *Lind.*							*																																		
S. Waltoni, *Dav.*							*																																		
S. ornatella, *Salt.*								*																																	
LEPTÆNA *(Orthidæ).*																																									
L. sericea, *Sow.*			*	*	*	*	?					?																													
var. rhombica, *M'Coy.*				*																																					
L. tenuicincta, *M'Coy*			*	*	?																																				
L. quinquecostata, *M'Coy.*				*	*	*																																			
L. scissa, *Salt.*				*	*	*																																			
L. tenuissimestriata, *M'Coy.*				*																																					
L. transversalis, *Wahl.*				*	*	*	*																																		
var. Youngiana, *Dav.*				*																																					
L. lævigata, *Sow.*							*	*				?																													
L. segmentum, *Angelin*							*																																		
L. laticosta, *Conrad.*									*																																
L. interstrialis, *Phill.*										*																															
L. nobilis, *M'Coy*																																									

[illegible]	...	...	...	...																																					
L. Moorei, *Dav.*	...	...	...	...																																					
RHYNCHONELLA (*Rhynchonellidæ*).																																									
R. Salteri, *Dav.*	...	...	*	*																																					
R. æmula, *Salt.*	...	...	...	*																																					
R. nana, *Salt.*	...	...	...	*																																					
R. nasuta, *M'Coy.*	...	...	...	*																																					
R. Portlockiana, *Dav.*	...	...	...	*																																					
R. tripartita, *Sow.*	...	...	...	*	*																																				
R. borealis, *Schl.*	...	...	...	...	*	*	*	*																																	
R. Llandoveriana, *Dav.*	...	...	...	...	*	*																																			
R. nucula, *Sow.*	...	...	...	...	?	*	*																																		
R. decemplicata, *Sow.*	...	...	...	...	...	*	?	*																																	
R. Lewisii, *Dav.*	...	...	...	...	...	?	*																																		
R. Weaveri, *Salt.*	...	...	...	...	...	*																																			
R. Beltiana, *Dav.*	...	...	...	...	...	...	*																																		
R. cuneata, *Dal.*	...	...	...	...	...	...	*																																		
R. deflexa, *Sow.*	...	...	...	...	...	...	*																																		
R. navicula, *Sow.*	...	...	...	...	...	...	*	*																																	
R. Stricklandii, *Sow.*	...	...	...	...	...	...	*																																		
R. Wilsoni, *Sow.*	...	...	...	...	...	...	*	*																																	
var. Davidsoni, *M'Coy*	...	...	...	...	...	...	*	*																																	
var. sphæroidalis, *M'Coy.*	...	...	...	...	...	...	*																																		
R. Pentlandica, *Haswell.*	...	...	...	...	...	...	...	*																																	
R. bifera, *Phill.*	...	...	...	...	...	...	...	...	*	*																															
R. cuboides, *Sow.*	...	...	...	...	...	...	...	...	*	*																															
R. Pengelliana, *Dav.*	...	...	...	...	...	...	...	...	*																																
R. pleurodon, *Phill.*	...	...	...	...	...	...	...	...	*	*	*	*	*																												
R. protracta, *Sow.*	...	...	...	...	...	...	...	...	*	*																															
R. acuminata, *Mart.*	...	...	...	...	...	...	...	...	...	*	*	*																													
R. angularis, *Phill.*	...	...	...	...	...	...	...	...	...	*																															
R. laticosta, *Phill.*	...	...	...	...	...	...	...	...	...	*	*	*																													
R. Lummatoniensis, *Dav.*	...	...	...	...	...	...	...	...	...	*																															
R. Ogwelliensis, *Dav.*	...	...	...	...	...	...	...	...	...	*																															
R. primipilaris, *V. Buch.*	...	...	...	...	...	...	...	...	...	*																															
var. implexa, *Sow.*	...	...	...	...	...	...	...	...	...	*																															
R. pugnus, *Martin.*	...	...	...	...	...	...	...	...	...	*	*	*																													
R. reniformis, *Sow.*	...	...	...	...	...	...	...	...	...	*	*	*																													
R. sphærica, *Sow.*	...	...	...	...	...	...	...	...	...	*																															
R. triloba, *Sow.*	...	...	...	...	...	...	...	...	...	*																															
R. subdentata, *Phill.*	...	...	...	...	...	...	...	...	...	...	*																														

TABLE I. *(continued).—Showing the Stratigraphical Range of each Genus and Species of British Fossil Brachiopoda.*

GENERA and SPECIES.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	
	PALÆOZOIC.															MESOZOIC.																			CAINOZOIC.						
	CAMB.	SILURIAN. (Of Murchison.)							DEVONIAN.			CARBONIFEROUS.			PER.	TRIASSIC.			JURASSIC.											CRETACEOUS.					TERTIARY.						
	Cambrian.	Primordial Silurian.	Llandeilo.	Caradoc.	Lower Llandovery.	Upper Llandovery.	Wenlock.	Ludlow.	Lower Devonian.	Middle Devonian.	Upper Devonian.	Carb. Limestone.	Millstone Grit.	Coal Measures.	Permian.	Bunter.	Keuper.	Rhætic.	Lower Lias.	Middle Lias.	Upper Lias.	Inferior Oolite.	Great Oolite.	Crb., For. Mar., & Br. Cl.	Oxford Clay.	Coralline Oolite.	Kimmeridge Clay.	Portland.	Purbeck.	Wealden.	Lower Greensand.	Gault.	Upper Greensand.	Chalk.	Lower Eocene.	Middle Eocene.	Upper Eocene.	Miocene.	Older Pliocene.	Newer Pliocene.	Recent.
RHYNCHONELLA *(continued).*																																									
R. angulata, *Linn.*												*																													
R. Carringtoniana, *Dav.*												*																													
R. cordiformis, *Sow.*												*																													
R. flexistra, *Phill.*												*																													
R. gregaria, *M'Coy.*												*																													
R. proava, *Phill.*												*																													
R. semisulcata, *M'Coy.*												*																													
R. trilatera, *De Kon.*												*																													
R. Wettonensis, *Dav.*												*																													
R. oxynoti, *Quenst.*																			*																						
R. plicatissima, *Quenst.*																			*																						
R. rimosa, *V. Buch.*																			*	*																					
R. variabilis, *Schl.*																			*	*	*	*																			
var. bidens, *Phill.*																				*		*																			
var. triplicata, *Phill.*																						*																			
R. acuta, *Sow.*																				*		*																			
R. concinna, *Sow.*																				*		*	*	*																	
R. cynocephala, *Rich.*																				*	*	*																			
R. egretta, *Deslong.*																				*																					
R. furcillata, *Theodori*																				*	*																				
R. Moorei, *Dav.*																				*	p																				
R. serrata, *Sow.*																				*		*																			

R. subserrata, *Munst.*	R. subtetraëdra, *Dav.*	R. subvariabilis, *Dav.*	R. tetraëdra, *Sow.*	R. Bouchardii, *Dav.*	R. coronata, *Moore.*	R. Jurensis, *Quenst.*	R. Lycettii, *Dav.*	R. plicatella, *Sow.*	R. pygmæa, *Morris*	R. angulata, *Sow.*	R. Crossii, *Walker*	R. Forbesii, *Dav.*	R. inconstans, *Sow.*	R. obsoleta, *Sow.*	R. Oolitica, *Dav.*	R. quadriplicata, *Zeiten.*	R. ringens, *Herault.*	R. senticosa, *V. Buch.*	R. spinosa, *Schl.*	R. subdecorata, *Dav.*	R. subobsoleta, *Dav.*	R. subringens, *Dav.*	R. triangularis, *Moore.*	R. varians, *Schl.*	R. Wrightii, *Dav.*	R. Moorei, *Dav.*	R. lacunosa, *Schl.*	R. antidichotoma, *Buv.*	R. depressa, *Sow.*	*var.* A. *Dav.*	*var.* B. *Dav.*	R. elegans, *Sow.*	R. Gibbsiana, *Sow.*	R. latissima, *Sow.*	R. nuciformis, *Sow.*	R. parvirostris, *Sow.*	R. sulcata, *Park.*	R. compressa, *Lam.*	R. Grasiana, *D'Orb.*	R. limbata, *Schl.*	R. lineolata, *Phill.*
																													*	*	*			*	*			*	*	*	*
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*	*	*	*																																						

TABLE I. (*continued*).—*Showing the Stratigraphical Range of each Genus and Species of British Fossil Brachiopoda.*

GENERA and SPECIES.	1 Cambrian.	2 Primordial Silurian.	3 Llandeilo.	4 Caradoc.	5 Lower Llandovery.	6 Upper Llandovery.	7 Wenlock.	8 Ludlow.	9 Lower Devonian.	10 Middle Devonian.	11 Upper Devonian.	12 Carb. Limestone.	13 Millstone Grit.	14 Coal Measures.	15 Permian.	16 Bunter.	17 Keuper.	18 Rhætic.	19 Lower Lias.	20 Middle Lias.	21 Upper Lias.	22 Inferior Oolite.	23 Great Oolite.	24 Crb., For. Mar., & Br. Cl.	25 Oxford Clay.	26 Coralline Oolite.	27 Kimmeridge Clay.	28 Portland.	29 Purbeck.	30 Wealden.	31 Lower Greensand.	32 Gault.	33 Upper Greensand	34 Chalk.	35 Lower Eocene.	36 Middle Eocene.	37 Upper Eocene.	38 Miocene.	39 Older Pliocene.	40 Newer Pliocene.	Recent.
	PALÆOZOIC. CAMB.	SILURIAN. (Of Murchison.)							DEVONIAN.			CARBONIFEROUS.			PER.	MESOZOIC. TRIASSIC.			JURASSIC.											CRETACEOUS.					CAINOZOIC. TERTIARY.						
RHYNCHONELLA (*continued*).																																									
R. Mantelliana, *Sow.*																																	*	*							
R. Martini, *Mant.*																																	*	*							
R. Cuvieri, *D'Orb.*																																		*							
R. plicatilis, *Sow.*																																		*							
var. octoplicata, *Sow.*																																		*							
var. Woodwardii, *Dav.*																																		*							
R. psittacea, *Chem.*																																							*	*	4 sps. Northern Seas.
PORAMBONITES (*Rhynchonellidæ*).																																									
P. intercedens, *Pand.*																																									
var. filosa, *M'Coy*				*																																					
ATRYPA (*Spiriferidæ*).																																									
A. apiculata, *Salt.*				*																																					
A. imbricata, *Sow.*				*	*	*	*																																		
A. marginalis, *Dal.*				*	*	*	*																																		
A. hemisphærica, *Sow.*					*	*																																			
A. reticularis, *Linn.*					*	*	*	*	*	*	*																														
A. Scotica, *M'Coy.*					*																																				
A. incerta, *Dav.*						*																																			
A. Grayii, *Dav.*							*																																		
A. aspera, *Schloth.*									*	*	*																														

A. flabellata, *Goldf.* ...											*																								
A. lepida, *Goldf.*											*																								
Merista (*Spiriferidæ*).																																			
M. cymbula, *Dav.*					*																														
M. plebeia, *Sow.*											*		*																						
Crania (*Craniadæ*).																																			
C. divaricata, *M'Coy.* ...					*																														
C. implicata, *Sow.*							*	*	*																										
C. Grayii, *Dav.*								*																											
C. Siluriana, *Dav.*								*																											
C. quadrata, *M'Coy* ...													*																						
C. Ryckholtiana, *De Kon.*													*																						
C. trigonalis, *M'Coy* ...													*																						
C. Kirkbyii, *Dav.*																*																			
C. Liassica, *Moore*... ...																				*															
C. Gumberti, *Deslong* ...																						*													
C. Moorei, *Dav.*																						*													
C. canalis, *Moore.*																							*												
C. Sandersii, *Moore.* ...																							*												
C. antiquor, *Jelly*																								*											
C. Ponsorti, *Deslong.* ...																								*											
C. cenomanensis, *D'Orb.* ...																																*			
C. costata, *Sow.?*																																			*
C. Ignabergensis, *Retzius.*																																			*
C. Parisiensis, *Def.*... ...																																			*
Orthisina (*Orthidæ*).																																			
O. adscendens, *Pand.* ...						*																													
Stricklandinia (*Rhynchonellidæ*).																																			
S. lens, *Sow.*						*	*																												
S. lirata, *Sow.*						*	*	*																											
Meristella (*Spiriferidæ*).																																			
M. angustifrons, *M'Coy.* ...						*																													
M. crassa, *Sow.*						*	*																												
M. subundata, *M'Coy* ...						*																													
M. didyma, *Dal.*							*	*	*																										
M. furcata, *Sow.*							*																												

5 sps. Nor., Trop., and Sou. Seas.

TABLE I. *(continued).—Showing the Stratigraphical Range of each Genus and Species of British Fossil Brachiopoda.*

GENERA and SPECIES.*	PALÆOZOIC.															MESOZOIC.																			CAINOZOIC.						
	CAMB	SILURIAN. (Of Murchison.)							DEVONIAN.			CARBONIFEROUS.			PER.	TRIASSIC.			JURASSIC.											CRETACEOUS.					TERTIARY.						
	Cambrian.	Primordial Silurian.	Llandeilo.	Caradoc.	Lower Llandovery.	Upper Llandovery.	Wenlock.	Ludlow.	Lower Devonian.	Middle Devonian.	Upper Devonian.	Carb. Limestone.	Millstone Grit.	Coal Measures.	Permian.	Bunter.	Keuper.	Rhætic.	Lower Lias.	Middle Lias.	Upper Lias.	Inferior Oolite.	Great Oolite.	Crb., For. Mar., & Br. Cl.	Oxford Clay.	Coralline Oolite.	Kimmeridge Clay.	Portland.	Purbeck.	Wealden.	Lower Greensand.	Gault.	Upper Greensand	Chalk.	Lower Eocene.	Middle Eocene.	Upper Eocene.	Miocene.	Older Pliocene.	Newer Pliocene.	Recent.
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	
MERISTELLA *(continued).*																																									
M. Circe, *Barr.*	...	...	...	...	...	...	*																																		
M. Maclareni, *Has.*	...	...	...	...	...	...	*																																		
M. nitida, *Hall.*	...	...	...	...	...	...	*																																		
M. tumida, *Dal.*	...	...	...	...	...	...	*	*	...	...	...	?																													
PENTAMERUS *(Rhynchonellidæ).*																																									
P. globosus, *Sow.*	...	...	...	...	*	*																																			
P. oblongus, *Sow.*	...	...	...	...	*	*																																			
P. undatus, *Sow.*	...	...	...	...	*	*	?																																		
P. linguifer, *Sow.*	...	...	...	...	...	?	*																																		
P. rotundus, *Sow.*	...	...	...	...	...	?	*																																		
P. galeatus, *Dal.*	...	...	...	...	...	...	*	*																																	
P. Knightii, *Sow.*	...	...	...	...	...	...	*	*																																	
P. biplicatus, *Schnur.*	...	...	...	...	...	...	...	...	...	*																															
P. brevirostris, *Phill.*	...	...	...	...	...	...	...	...	...	*																															
CYRTIA *(Spiriferidæ).*																																									
O. exporrecta, *Dal.*...	...	...	...	...	*	*	*	*																																	
C. nasuta, *Linds.*	...	...	...	...	...	...	*																																		
SPIRIFERA *(Spiriferidæ).*																																									
S. crispa, *His.*																																									

S. plicatella, *Linn.*	...	...	...	...	...	...	*	*																																	
var. radiata, *Sow.*	...	...	...	...	P	...	*	*																																	
var. globosa, *Salt.*	...	...	...	...	...	...	*																																		
S. bijugosa, *M'Coy*	...	...	...	...	...	...	*																																		
S. sulcata, *His.*	...	...	...	...	...	...	*																																		
S. canalifera, *Val.*	...	...	...	...	...	...	...	...	*	*																															
S. cultrijugata, *Roem.*	...	...	...	...	...	...	...	...	*																																
S. curvata, *Schl.*	...	...	...	...	...	...	...	...	*	*																															
S. hysterica, *Schl.*	...	...	...	...	...	...	...	...	*	*																															
S. lævicosta, *Val.*	...	...	...	...	...	...	...	...	*	*	...	?																													
S. speciosa, *Schl.*	...	...	...	...	...	...	...	...	*	*	...	?																													
S. undifera, *Roem.*	...	...	...	...	...	...	...	...	*	*																															
var. undulata, *Roem.*	...	...	...	...	...	...	...	...	*	*																															
S. comprimata, *Schl.*	...	...	...	...	...	...	...	...	...	*																															
S. disjuncta, *Sow.*	...	...	...	...	...	...	...	...	...	*	*																														
S. glabra, *Mart.*	...	...	...	...	...	...	...	...	...	*	...	*																													
S. lineata, *Mart.*	...	...	...	...	...	...	...	...	...	*	*	*																													
S. Newtoniensis, *Dav.*	...	...	...	...	...	...	...	...	...	...	...	*																													
S. nuda, *Sow.*	...	...	...	...	...	...	...	...	...	*																															
S. simplex, *Phill.*	...	...	...	...	...	...	...	...	...	*																															
S. subcuspidata, *Schl.*	...	...	...	...	...	...	...	...	...	*																															
S. Urii, *Flem.*	...	...	...	...	...	...	...	...	...	*																															
S. laminosa, *M'Coy.*	...	...	...	...	...	...	...	...	...	*	*	*	...	...	*																										
S. megaloba, *Phill.*	...	...	...	...	...	...	...	...	...	...	*	*																													
S. mesomala, *Phill.*	...	...	...	...	...	...	...	...	...	...	*	?																													
S. obliterata, *Phill.*	...	...	...	...	...	...	...	...	...	...	*	?																													
S. rudis, *Phill.*	...	...	...	...	...	...	...	...	...	...	*																														
S. trigonalis, *Mart.*	...	...	...	...	...	...	...	...	...	...	*	?																													
S. acuta, *Mart.*	...	...	...	...	...	...	...	...	...	...	*	*	*																												
S. Carlukensis, *Dav.*	...	...	...	...	...	...	...	...	...	...	...	*																													
S. convoluta, *Phill.*	...	...	...	...	...	...	...	...	...	...	...	*																													
S. cuspidata, *Mart.*	...	...	...	...	...	...	...	...	...	...	...	*																													
S. decemcostata, *M'Coy.*	...	...	...	...	...	...	...	...	...	...	...	*																													
S. duplicicosta, *Phill.*	...	...	...	...	...	...	...	...	...	...	...	*																													
var. humerosa, *Phill.*	...	...	...	...	...	...	...	...	...	...	...	*																													
S. elongata, *Phill.*	...	...	...	...	...	...	...	...	...	...	...	*																													
S. elliptica, *Phill.*	...	...	...	...	...	...	...	...	...	...	...	*																													
S. fusiformis, *Phill.*	...	...	...	...	...	...	...	...	...	...	...	*																													
S. integricosta, *Phill.*	...	...	...	...	...	...	...	...	...	...	...	*																													
S. mesogonia, *M'Coy.*	...	...	...	...	...	...	...	...	...	...	...	*																													
S. Mosquensis, *Fisch.*	...	...	...	...	...	...	...	...	...	...	...	*																													
S. ovalis, *Phill.*	...	...	...	...	...	...	...	...	...	...	...	*																													

TABLE I. (*continued*).—*Showing the Stratigraphical Range of each Genus and Species of British Fossil Brachiopoda.*

GENERA and SPECIES.	PALÆOZOIC.															MESOZOIC.																			CAINOZOIC.						
	CAMB.	SILURIAN. (Of Murchison.)							DEVONIAN.			CARBONIFEROUS.			PER.	TRIASSIC.			JURASSIC.											CRETACEOUS.					TERTIARY.						
	Cambrian.	Primordial Silurian.	Llandeilo.	Caradoc.	Lower Llandovery.	Upper Llandovery.	Wenlock.	Ludlow.	Lower Devonian.	Middle Devonian.	Upper Devonian.	Carb. Limestone.	Millstone Grit.	Coal Measures.	Permian.	Bunter.	Keuper.	Rhœtic.	Lower Lias.	Middle Lias.	Upper Lias.	Inferior Oolite.	Great Oolite.	Crb., For. Mar., & Br. Cl.	Oxford Clay.	Coralline Oolite.	Kimmeridge Clay.	Portland.	Purbeck.	Wealden.	Lower Greensand.	Gault.	Upper Greensand.	Chalk.	Lower Eocene.	Middle Eocene.	Upper Eocene.	Miocene.	Older Pliocene.	Newer Pliocene.	Recent.
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	
SPIRIFERA (*continued*).																																									
S. pinguis, *Sow.*												*																													
S. planata, *Phill.*												*																													
S. Reedii, *Dav.*												*																													
S. rhomboidea, *Phill.*												*																													
S. striata, *Mart.*												*																													
S. subconica, *Mart.*												*																													
S. triangularis, *Mart.*												*																													
S. triradialis, *Phill.*												*																													
S. alata, *Schl.*															*																										
var. Permiana															*																										
CHONETES (*Productidæ*).																																									
C. minima, *Sow.*						*	*	*																																	
C. striatella, *Dalm.*						*	*	*				?																													
C. lepisma, *Sow.*								*																																	
C. Hardrensis, *Phill.*									*	*	*	*	*																												
C. minuta, *Goldf.*										*																															
C. Buchiana, *De Kon.*												*																													
C. concentrica, *De Kon.*												*																													
C. Dalmaniana, *De Kon.*												*																													
C. dilatata, *De Kon.*												*																													
C. gibberula, *M'Coy*												*																													

C. [illegible]	...	...	...	...	...	...	...	...	...	...	...	...	*	
C. papilionacea, *Phill.* ...	...	...	...	...	...	...	...	...	...	...	...	...	*	
C. perlata, ? *M'Coy.* ...	...	...	...	...	...	...	...	...	...	...	...	...	*	
C. polita, *M'Coy.* ...	...	...	...	...	...	...	...	...	...	...	...	...	*	
C. serrata, *M'Coy....* ...	...	...	...	...	...	...	...	...	...	...	...	...	*	
C. subminima, ? *M'Coy.* ...	...	...	...	...	...	...	...	...	...	...	...	...	*	
C. tuberculata, *M'Coy.* ...	...	...	...	...	...	...	...	...	...	...	...	...	*	
C. variolata, ? *D'Orb.* ...	...	...	...	...	...	...	...	...	...	...	...	...	*	
C. volva, ? *M'Coy....* ...	...	...	...	...	...	...	...	...	...	...	...	...	*	
ORBICULOIDEA *(Discinidæ).*														
O. Beckettiana, *Dav.* ...	...	...	...	...	...	...	...	*						
O. Forbesii, *Dav.*	...	...	...	...	...	...	...	*						
EICHWALDIA (*Rhynchonellidæ*).														
E. Capewelli, *Dav....* ...	...	...	...	...	...	...	...	*						
NUCLEOSPIRA *(Spiriferidæ).*														
N. pisum, *Sow.*	...	...	...	...	...	...	...	*						
RETZIA *(Spiriferidæ).*														
R. Barrandii, *Dav.* ...	...	...	...	...	...	...	...	*						
R. Salteri, *Dav.*	...	...	...	...	...	...	...	*						
var. Baylei, *Dav.* ...	...	...	...	...	...	...	...	*	*					
var. Boucharii, *Dav.* ...	...	...	...	...	...	...	...	*						
R. ferita, *V. Buch.* ...	...	...	...	...	...	...	...	...	...	...	*			
R. carbonaria, *Dav.* ...	...	...	...	...	...	...	...	...	...	...	...	...	*	
R. radialis, *Phill.*	...	...	...	...	...	...	...	...	...	...	...	...	*	
R. ulotrix, *De Kon.* ...	...	...	...	...	...	...	...	...	...	...	...	...	*	
ATHYRIS *(Spiriferidæ).*														
A. compressa, *Sow.* ...	...	...	...	...	...	...	...	*						
A. depressa, *Sow.*	...	...	...	...	...	...	...	*						
A. obovata, *Sow.*	...	...	...	...	...	...	...	...	*					
A. concentrica, *V. Buch.* ...	...	...	...	...	...	...	...	...	...	*	*	*	?	
A. phalæna, *Phill....* ...	...	...	...	...	...	...	...	...	...	*	*	...	*	
A. Bartoniensis, *Dav.* ...	...	...	...	...	...	...	...	...	...	...	*			
A. Newtoniensis, *Dav.* ...	...	...	...	...	...	...	...	...	...	...	*			
A. decussata, *Sow....* ...	...	...	...	...	...	...	...	...	...	...	...	*	?	
A. indentata, *Sow....* ...	...	...	...	...	...	...	...	...	...	...	...	*	*	
A. oblonga, *Sow.*	...	...	...	...	...	...	...	...	...	...	...	*		
A. ambigua, *Sow.*	...	...	...	...	...	...	...	...	...	...	...	...	*	*
A. Carringtoniana, *Dav.* ...	...	...	...	...	...	...	...	...	...	...	...	...	*	

TABLE I. (*continued*).—*Showing the Stratigraphical Range of each Genus and Species of British Fossil Brachiopoda.*

GENERA and SPECIES.	PALÆOZOIC.															MESOZOIC.																			CAINOZOIC.						
	CAMB.	SILURIAN. (Of Murchison.)							DEVONIAN.			CARBONIFEROUS.			PER.	TRIASSIC.			JURASSIC.											CRETACEOUS.					TERTIARY.						
	Cambrian.	Primordial Silurian.	Llandeilo.	Caradoc.	Lower Llandovery.	Upper Llandovery.	Wenlock.	Ludlow.	Lower Devonian.	Middle Devonian.	Upper Devonian.	Carb. Limestone.	Millstone Grit.	Coal Measures.	Permian.	Bunter.	Keuper.	Rhætic.	Lower Lias.	Middle Lias.	Upper Lias.	Inferior Oolite.	Great Oolite.	Crb., For. Mar., & Br. Cl.	Oxford Clay.	Coralline Oolite.	Kimmeridge Clay.	Portland.	Purbeck.	Wealden.	Lower Greensand.	Gault.	Upper Greensand	Chalk.	Lower Eocene.	Middle Eocene.	Upper Eocene.	Miocene.	Older Pliocene.	Newer Pliocene.	Recent.
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	
ATHYRIS (*continued*).																																									
A. expansa, *Phill.*												*																													
A. globularis, *Phill.*												*																													
A. lamellosa, *L'Ev.*												*																													
A. planosulcata, *Phill.*												*																													
A. Royssii, *L'Ev.*												*																													
A. squamigera, *De Kon.*												*																													
A. subtilita, *Hall.*												*																													
A. trilobata, *M'Coy.*												*																													
A. pectinifera, *Sow.*															*																										
STREPTORHYNCHUS (*Orthidæ*).																																									
S. crenistria, *Phill.*									*	*	*	*	*																												
var. arachnoidea, *Phill.*											*	*																													
var. cylindrica, *M'Coy.*												*																													
var. Kellii, *M'Coy.*												*																													
var. radialis, *Phill.*												*																													
S. gigas, *M'Coy.*									*																																
S. persarmentosus, *M'Coy.*									*																																
S. umbraculum, *Schl.*									*	*																															
S. plicata, *Sow.*											*																														
S. semicircularis, *Phill.*											*																														
S. pelargonatus, *Schl.*															*																										

Spiriferina (*Spiriferidæ*).																																									
S. cristata, *Schl.*	...	...	...	...	...	...	...	...	*	*	*	...	...	...	*																										
var. biplicata, *Dav.*	...	...	...	...	...	...	...	...	...	...	...	*																													
var. octoplicata, *Sow.*	...	...	...	...	...	...	...	...	...	...	...	*	...	...	*																										
S. insculpta, *Phill.*	...	...	...	...	...	...	...	...	...	*	...	*																													
S. minima, *Sow.*	...	...	...	...	...	...	...	...	...	...	...	*																													
S. multiplicata, *Sow.*	...	...	...	...	...	...	...	...	...	...	...	...	...	...	*																										
S. rostrata, *Schl.*	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	*	*	*																				
S. Walcottii, *Sow.*	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	*	*																					
S. Deslongchampsi, *Dav.*	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	*																					
S. Münsteri, *Dav.*	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	*	*																				
S. oxygona, *Deslong.*	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	*																					
S. oxyptera, *Buvig.*	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	*																					
S. verrucosa, *V. Buch.*	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	*																					
S. Ilminsteriensis, *Dav.*	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	*																				
S. Oolitica, *Moore.*	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	*																			
Davidsonia (*Orthidæ*).																																									
D. Verneuilii, *Bouch.*	...	...	...	...	...	...	...	...	...	*																															
Calceola (*Calceolidæ*).																																									
C. sandalina, *Linn.*	...	...	...	...	...	...	...	...	...	*																															
Stringocephalus (*Terebratulidæ*).																																									
S. Burtini, *Defr.*	...	...	...	...	...	...	...	...	...	*																															
Uncites (*Spiriferidæ*).																																									
U. gryphus, *Schl.*	...	...	...	...	...	...	...	...	...	*																															
Cyrtina (*Spiriferidæ*).																																									
C. amblygona, *Phill.*	...	...	...	...	...	...	...	...	...	*																															
C. Demarlii, *Bouch.*	...	...	...	...	...	...	...	...	...	*																															
C. heteroclyta, *Defr.*	...	...	...	...	...	...	...	...	...	*																															
C. multiplicata, *Dav.*	...	...	...	...	...	...	...	...	...	*																															
C. carbonaria, *M'Coy.*	...	...	...	...	...	...	...	...	...	...	...	*																													
C. dorsata, *M'Coy.*	...	...	...	...	...	...	...	...	...	...	...	*																													
C. septosa, *Phill.*	...	...	...	...	...	...	...	...	...	...	...	*																													
Rensselæria (*Terebratulidæ*).																																									
R. stringiceps, *Roem.*	...	...	...	...	...	...	...	...	...	*	...	?																													
Productus (*Productidæ*).																																									
P. subaculeatus, *Murch.*	...	...	...	...	...	...	...	...	...	*	*	?																													

TABLE I. (*continued*).—*Showing the Stratigraphical Range of each Genus and Species of British Fossil Brachiopoda.*

GENERA and SPECIES.	PALÆOZOIC.															MESOZOIC.																			CAINOZOIC.						
	CAMB.	SILURIAN. (Of Murchison.)							DEVONIAN.			CARBONIFEROUS.			PER.	TRIASSIC.			JURASSIC.											CRETACEOUS.					TERTIARY.						
	Cambrian.	Primordial Silurian.	Llandello.	Caradoc.	Lower Llandovery.	Upper Llandovery.	Wenlock.	Ludlow.	Lower Devonian.	Middle Devonian.	Upper Devonian.	Carb. Limestone.	Millstone Grit.	Coal Measures.	Permian.	Bunter.	Keuper.	Rhaetic.	Lower Lias.	Middle Lias.	Upper Lias.	Inferior Oolite.	Great Oolite.	Crb., For. Mar., & Br. Cl.	Oxford Clay.	Coralline Oolite.	Kimmeridge Clay.	Portland.	Purbeck.	Wealden.	Lower Greensand.	Gault.	Upper Greensand.	Chalk.	Lower Eocene.	Middle Eocene.	Upper Eocene.	Miocene.	Older Pliocene.	Newer Pliocene.	Recent.
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	
PRODUCTUS (*continued*).																																									
P. interruptus, *Sow.*	...	...	...	...	...	...	...	...	...	*	...																														
P. longispinus, *Sow.*	...	...	...	...	...	...	...	...	...	...	*																														
P. prælongus, *Sow.*	...	...	...	...	...	...	...	...	...	...	*	?																													
P. scabriculus, *Mart.*	...	...	...	...	...	...	...	...	...	...	*	*																													
P. aculeatus, *Mart.*	...	...	...	...	...	...	...	...	...	...	...	*																													
P. arcuarius, *De Kon.*	...	...	...	...	...	...	...	...	...	...	...	*																													
P. carbonarius, *De Kon.*	...	...	...	...	...	...	...	...	...	...	...	*																													
P. Carringtonianus, *Dav.*	...	...	...	...	...	...	...	...	...	...	...	*																													
P. comoides, *Sow.*	...	...	...	...	...	...	...	...	...	...	...	*																													
P. concinnus, *Sow.*	...	...	...	...	...	...	...	...	...	...	...	*	*																												
P. Cora, *D'Orb.*	...	...	...	...	...	...	...	...	...	...	...	*	*																												
P. costatus, *Sow.*	...	...	...	...	...	...	...	...	...	...	...	*																													
var. muricatus, *Phill.*	...	...	...	...	...	...	...	...	...	...	...	*																													
P. Deshaysianus, *De Kon.*	...	...	...	...	...	...	...	...	...	...	...	*																													
P. ermineus, *De Kon.*	...	...	...	...	...	...	...	...	...	...	...	*																													
P. fimbriatus, *Sow.*	...	...	...	...	...	...	...	...	...	...	...	*																													
P. giganteus, *Mart.*	...	...	...	...	...	...	...	...	...	...	...	*																													
var. hemisphæricus, *Sow.*	...	...	...	...	...	...	...	...	...	...	...	*																													
P. Griffithianus, *De Kon.*	...	...	...	...	...	...	...	...	...	...	...	*																													
P. humerosus, *Sow.*	...	...	...	...	...	...	...	...	...	...	...	*																													
P. intermedius, *M'Coy.*	...	...	...	...	...	...	...	...	...	...	...	*																													
P. Keyserlingianus, *De Kon.*	...	...	...	...	...	...	...	...	...	...	...	*																													

P. Koninckianus, *De Vern.*	...	...	...	...	...	...	...	...	...	...	...	...	*																													
P. latissimus, *Sow.*	...	...	...	...	...	...	...	...	...	...	...	...	*																													
P. Leuchtenburgensis? *De Kon.*	...	...	...	...	...	...	...	...	...	...	...	...	*																													
P. Llangollensis, *Dav.*	...	...	...	...	...	...	...	...	...	...	...	...	*																													
P. longispinus, *Sow.*	...	...	...	...	...	...	...	...	...	...	...	...	*	*																												
P. margaritaceus, *Phill.*	...	...	...	...	...	...	...	...	...	...	...	...	*																													
P. marginalis, *De Kon.*	...	...	...	...	...	...	...	...	...	...	...	...	*																													
P. maximus, *M'Coy.*	...	...	...	...	...	...	...	...	...	...	...	...	*																													
P. mesolobus, *Phill.*	...	...	...	...	...	...	...	...	...	...	...	...	*																													
P. Nystianus, *De Kon.*	...	...	...	...	...	...	...	...	...	...	...	...	*																													
P. plicatilis, *Sow.*	...	...	...	...	...	...	...	...	...	...	...	...	*																													
P. proboscideus, *De Vern.*	...	...	...	...	...	...	...	...	...	...	...	...	*																													
P. pugilis, *Phill.*	...	...	...	...	...	...	...	...	...	...	...	...	*																													
P. punctatus, *Mart.*	...	...	...	...	...	...	...	...	...	...	...	...	*																													
var. elegans, *M'Coy.*	...	...	...	...	...	...	...	...	...	...	...	...	*																													
P. pustulosus, *Phill.*	...	...	...	...	...	...	...	...	...	...	...	...	*																													
P. semireticulatus, *Mart.*	...	...	...	...	...	...	...	...	...	...	...	...	*	*																												
P. sinuatus, *De Kon.*	...	...	...	...	...	...	...	...	...	...	...	...	*																													
P. spinulosus, *Sow.*	...	...	...	...	...	...	...	...	...	...	...	...	*																													
P. striatus, *Fisch.*	...	...	...	...	...	...	...	...	...	...	...	...	*																													
P. sublævis, *De Kon.*	...	...	...	...	...	...	...	...	...	...	...	...	*																													
P. tessellatus, *De Kon.*	...	...	...	...	...	...	...	...	...	...	...	...	*																													
P. undatus, *Def.*	...	...	...	...	...	...	...	...	...	...	...	...	*	*																												
P. undiferus, *De Kon.*	...	...	...	...	...	...	...	...	...	...	...	...	*																													
P. Wrightii, *Dav.*	...	...	...	...	...	...	...	...	...	...	...	...	*																													
P. Youngianus, *Dav.*	...	...	...	...	...	...	...	...	...	...	...	...	*	*																												
P. horridus, *Sow.*	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	*																										
P. latirostratus, *Howse.*	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	*																										
CAMAROPHORIA *(Rhynchonellidæ).*																																										
C. rhomboidea, *Phill.*	...	...	...	...	...	...	...	...	...	...	*	*																														
C. crumena, *Mart.*	...	...	...	...	...	...	...	...	...	...	...	...	*	...	...	*																										
C. globulina, *Phill.*	...	...	...	...	...	...	...	...	...	...	...	...	*	...	...	*																										
C. isorhyncha, *M'Coy*	...	...	...	...	...	...	...	...	...	...	...	...	*																													
C. laticliva, *M'Coy.*	...	...	...	...	...	...	...	...	...	...	...	...	*																													
C. Humboldtonensis, *Howse.*	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	*																										
STROPHALOSIA *(Productidæ).*																																										
S. productoides, *Murch.*	...	...	...	...	...	...	...	...	...	...	*	*	*																													
S. Goldfussii, *Münst.*	...																																									
var. Lewisiana, *De Kon.*	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	*																										
S. lamellosa, *Geinitz.*	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	*																										
var. Humbletonensis, *King.*	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	*																										

TABLE I. *(continued).—Showing the Stratigraphical Range of each Genus and Species of British Fossil Brachiopoda.*

GENERA and SPECIES.	PALÆOZOIC. CAMB.	PALÆOZOIC. SILURIAN. (Of Murchison.)							DEVONIAN.			CARBONIFEROUS.			PER.	MESOZOIC. TRIASSIC.			JURASSIC.											CRETACEOUS.					CAINOZOIC. TERTIARY.						
	Cambrian. 1	Primordial Silurian. 2	Llandeilo. 3	Caradoc. 4	Lower Llandovery. 5	Upper Llandovery. 6	Wenlock. 7	Ludlow. 8	Lower Devonian. 9	Middle Devonian. 10	Upper Devonian. 11	Carb. Limestone. 12	Millstone Grit. 13	Coal Measures. 14	Permian. 15	Bunter. 16	Keuper. 17	Rhætic. 18	Lower Lias. 19	Middle Lias. 20	Upper Lias. 21	Inferior Oolite. 22	Great Oolite. 23	Crb., For. Mar., & Br. Cl. 24	Oxford Clay. 25	Coralline Oolite. 26	Kimmeridge Clay. 27	Portland. 28	Purbeck. 29	Wealden. 30	Lower Greensand. 31	Gault. 32	Upper Greensand. 33	Chalk. 34	Lower Eocene. 35	Middle Eocene. 36	Upper Eocene. 37	Miocene. 38	Older Pliocene. 39	Newer Pliocene. 40	Recent.
STROPHALOSIA *(continued).*																																									
var. Morrisiana, *King*....															*																										
S. Whitleyensis, *King*.												.			*																										
TEREBRATULA (*Terebratulidæ*).																																									
T. juvenis, *Sow*.										*		?																													
T. Newtoniensis, *Dav*.										*																															
T. sacculus, *Mart*. ...										*	*	*			*																										
T. elongata, *Schl*. ...												?			*																										
T. hastata, *Sow*. ...												*																													
var. ficus, *M'Coy*.												*																													
var. Gillingensis, *Dav*.												*																													
T. vesicularis, *De Kon*.												*																													
T. punctata, *Sow*. ...																			*	*																					
T. indentata, *Sow*....																				*																					
T. subpunctata, *Dav*.																				*	*																				
T. globulina, *Dav*....																					*																				
T. articulata, *Smith*																						*																			
T. Brebbisoni, *Des*.																						*																			
T. Buckmanii, *Dav*.																						*																			
T. equestris, *D'Orb*.																						*																			
T. Etheridgii, *Dav*.																						*																			
T. fimbria, *Sow*. ...																						*																			
T. galeiformis, *M'Coy*.																						*																			

T. intermedia, *Sow.*																						*	*	*		*								
T. Lyocettii, *Dav.*																						*												
T. maxillata, *Sow.*																						*	*	*										
T. ovoidea, *Sow.*																						*												
T. pentahedra, *Münst.*																						*												
T. perovalis, *Sow.*																						*	*		*									
T. Phillipsii, *Morris.*																						*												
T. plicata, *Buck.*																						*	*											
T. simplex, *Buck.*																						*												
T. sphæroidalis, *Sow.*																						*			*									
T. subglobata, *Sow.*																						*												
T. submaxillata, *Morris.*																						*		*										
T. Wrightii, *Dav.*																						*												
T. coarctata, *Park.*																							*	*	*									
T. hemisphærica, *Sow.*																							*											
T. minuta, *Moore.*																							*											
T. Bentleyi, *Morris.*																								*										
T. flabellum, *Def.*																								*										
T. bucculenta, *Sow.*																									*	*								
T. insignis, *Schubler.*																									*	*								
T. biplicata, *Brocchi.*																															*	*	*	*
var. Dutempliana, *D'Orb.*																																	*	*
T. Dallasii, *Walk.*																															*			
T. depressa, *Lam.*																															*			
var. Cantabridgiensis, *Walk.*																															*			
var. Cyrta, *Walk.*																															*			
var. uniplicata, *Walk.*																															*			
T. extensa, *Mey.*																															*			
T. Lankesteri, *Walk.*																															*			
T. lentoidea, *Leym.*																															*			
T. Meyeri, *Walk.*																															*			
T. microtrema, *Walk.*																															*			
T. ovata, *Sow.*																															*		*	*
T. prælonga, *Sow.*																															*			
T. Robertoni, *D'Arch.*																															*			
T. Seeleyi, *Walk.*																															*			
T. sella, *Sow.*																															*	*	?	?
var. Upwarensis, *Dav.*																															*			
T. Tornacensis, *D'Arch.*																																		
var. Rœmeri, *D'Arch.*																															*			
T. capillata, *D'Arch.*																																	*	
T. obesa, *Sow.*																																	*	*
T. semiglobosa, *Sow.*																																	*	*

TABLE I. (*continued*).—*Showing the Stratigraphical Range of each Genus and Species of British Fossil Brachiopoda.*

GENERA and SPECIES	PALÆOZOIC.															MESOZOIC.																			CAINOZOIC.						
	CAMB.	SILURIAN. (Of Murchison.)							DEVONIAN.			CARBONIFEROUS.			PER.	TRIASSIC.			JURASSIC.											CRETACEOUS.					TERTIARY.						
	Cambrian.	Primordial Silurian.	Llandeilo.	Caradoc.	Lower Llandovery.	Upper Llandovery.	Wenlock.	Ludlow.	Lower Devonian.	Middle Devonian.	Upper Devonian.	Carb. Limestone.	Millstone Grit.	Coal Measures.	Permian.	Bunter.	Keuper.	Rhætic.	Lower Lias.	Middle Lias.	Upper Lias.	Inferior Oolite.	Great Oolite.	Crb., For. Mar., & Br. Cl.	Oxford Clay.	Coralline Oolite.	Kimmeridge Clay.	Portland.	Purbeck.	Wealden.	Lower Greensand.	Gault.	Upper Greensand.	Chalk.	Lower Eocene.	Middle Eocene.	Upper Eocene.	Miocene.	Older Pliocene.	Newer Pliocene.	Recent.
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	
TEREBRATULA (*continued*).																																									3 sps. Med. & Atlan.
var. bulla, *Sow.*																																	*								
T. squamosa, *Mantell.*																																	*	*							
T. abrupta, *Tate.*																																		*							
T. carnea, *Sow.*																																		*							
T. Carteri, *Dav.*																																		*							
T. rugulosa, *Morris.*																																		*							
T. sulcifera, *Morris.*																																		*							
T. bisinuata, *Lam.*																																				*					
T. grandis, *Blum.*																																							*		
SYRINGOTHYRIS (*Spiriferidæ*).																																									
S. distans, *Sow.*											*																														
ZELLANIA (*Terebratulidæ*).																																									
Z. Davidsoni, *Moore.*																			*			*																			
Z. Laboucherei, *Moore.*																			*			*																			
Z. obesa, *Moore.*																			*																						
Z. Liasiana, *Moore.*																					*																				
Z. Oolitica, *Moore.*																						*																			
Z. globata, *Moore.*																							*	*		*															
THECIDIUM (*Thecideidæ*).																																									
T. Moorei, *Dav.*																			*	*	*																				

T. rusticum, *Moore*																				*	*	*																					
T. subserratum, *Tate.*																				*																							
T. triangulare, *D'Orb.*																				*	*	*	*	*	*		*																
T. Bouchardii, *Dav.*																					*	*	*																				
T. Deslongchampsii, *Dav.*																					*	*	*																				
T. granulosum, *Moore.*																					*		*																				
T. Dicksonii, *Moore.*																							*																				
T. duplicatum, *Moore.*																							*																				
T. Forbesii, *Moore.*																							*																				
T. serratum, *Moore.*																							*																				
T. septatum, *Moore.*																							*																				
T. ornatum, *Moore.*																											*														1 sp. Med.	
T. pygmæum, *Moore.*																											*																
T. Wetherellii, *Morris.*																																*			*								
WALDHEIMIA (*Terebratulidæ*).																																											
W. numismalis, *Lam.*																				*	*																						
W. perforata, *Piette.*																				*	*																						
W. cornuta, *Sow.*																					*																						
W. Heysiana, *Dunk.*																					*																						
W. Moorei, *Dav.*																					*																						
W. quadrifida, *Lam.*																					*																						
W. resupinata, *Sow.*																					*		*																				
W. subnumismalis, *Dav.*																					*																						
W. subovoides, *Roem.*																					*																						
W. Waterhousii, *Dav.*																					*																						
W. Lycettii, *Dav.*																						*																					
W. Bakeriæ, *Dav.*																							*																				
W. carinata, *Lam.*																							*																				
W. emarginata, *Sow.*																							*																				
W. impressa, *V. Buch.*																							*			*																	
W. ornithocephala, *Sow.*																							*		*	*	*																
W. Waltoni, *Dav.*																							*																				
W. cardium, *Lam.*																								*	*																		
W. digona, *Sow.*																								*	*																		
W. obovata, *Sow.*																								*	*	*	*																
W. rex, *Lank.*																													?														
W. celtica, *Morris.*																																*											
W. Juddii, *Walk.*																																*											
W. Morrissi, *Meÿ.*																																*											
W. pseudo-jurensis, *Leym.*																																*											
W. mutabilis, *Walk.*																																*											
var. elliptica, *Walk.*																																*											

TABLE I. *(continued).—Showing the Stratigraphical Range of each Genus and Species of British Fossil Brachiopoda.*

GENERA and SPECIES.	PALÆOZOIC.															MESOZOIC.																			CAINOZOIC.						
	CAMB.	SILURIAN. (Of Murchison.)							DEVONIAN.			CARBONIFEROUS.			PER.	TRIASSIC.			JURASSIC.											CRETACEOUS.					TERTIARY.						
	Cambrian.	Primordial Silurian.	Llandeilo.	Caradoc.	Lower Llandovery.	Upper Llandovery.	Wenlock.	Ludlow.	Lower Devonian.	Middle Devonian.	Upper Devonian.	Carb. Limestone.	Millstone Grit.	Coal Measures.	Permian.	Bunter.	Keuper.	Rhætic.	Lower Lias.	Middle Lias.	Upper Lias.	Inferior Oolite.	Great Oolite.	Crb., For. Mar., & Br. Cl.	Oxford Clay.	Coralline Oolite.	Kimmeridge Clay.	Portland.	Purbeck.	Wealden.	Lower Greensand.	Gault.	Upper Greensand.	Chalk.	Lower Eocene.	Middle Eocene.	Upper Eocene.	Miocene.	Older Pliocene.	Newer Pliocene.	Recent.
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	
WALDHEIMIA *(continued).*																																									9 sps. Nor. & Sou. Seas.
var. augusta, *Walk.*																															*										
W. tamarindus, *Sow.*																															*		*								
var. magna																															*										
W. Woodwardi, *Walk.*																															*										
W. Hibernica, *Tate.*																																	*								
SUESSIA (*Spiriferidæ*).																																									
S. imbricata, *Desl.*																				*																					
MEGERLIA (*Terebratulidæ*).																																									
M. Perrieri, *Deslong.*																				*																					
M. Suessi, *Deslong.*																				*																					
M. lima, *Def.*																																*	*	*							
TEREBRATELLA (*Terebratulidæ*).																																									...sps. Nor. & Sou. Seas.
T. Liasina, *Deslong.*																				*																					
T. Buckmanii, *Wood, M.S.*																							*																		
T. furcata, *Sow.*																							*																		
T. Davidsoni, *Walk.*																															*										
T. Fittoni, *Mey.*																															*										
T. Menardi, *Lam.*																															*			?							
T. oblonga, *Sow.*																															*		*								

T. trifida, *Meÿ.*																														*										25
T. pectita, *Sow.*																																*	*							
TEREBRATULINA (*Terebratulidæ*).																																								6 sps. Nor. & Sou. Seas.
T. Deslongchampsii, *Dav.*																			*																				
T. radiata, *Moore.*																					*	*																		
T. striata, *Wahl.*																														*		*	*							
var. pentagonalis, *Phill.*																														*										
T. gracilis, *Schl.*																															*	*	*							
var. rigida, *Sow.*																															*	?	*							
T. Defrancei, *Brong.*																																	*							
T. striatula, *Sow.*																																		*	*					
T. caput-serpentis, *Lin.*																																						*		
TEREBRIROSTRA (*Terebratulidæ*).																																								
T. lyra, *Sow.*																																*	*							
TRIGONOSEMUS (*Terebratulidæ*).																																								
T. incertus, *Dav.*																																?	*							
T. elegans, *Kœnig.*																																	*							
ARGIOPE (*Terebratulidæ*).																																								5 sps. Brit. & Med.
A. megatrema, *Sow.*																																*	?							
A. Bronnii, *De Hag.*																																	*							
A. cistellula, *Wood.*																																						*		
MAGAS (*Terebratulidæ*).																																								
M. pumila, *Sow.*																																	*							2 sps.

BUDLEIGH SALTERTON BRACHIOPODA.

In order to render this paper more complete, the following list of species of Brachiopoda obtained principally by Mr. Vicary, of Exeter, from the well-known Triassic pebble-bed at Budleigh Salterton, on the south coast of Devonshire, is given.

These species are not included in the Tables, because of the uncertainty of their age and original locality. They are found in pebbles of various, but uncertain ages according to some, and of the same age, but uncertain locality in the opinion of others. And as, moreover, the pebbles and the fossils they contain were at one time considered to afford indications that the rocks from which they were originally derived were outside of the British area, it is, perhaps, better to place the Brachiopoda found in the Budleigh Salterton pebbles in a separate and distinct list.

This list has been obtained from a paper "On the Brachiopoda hitherto obtained from the Pebble-bed of Budleigh Salterton, near Exmouth, in Devonshire," by Mr. Davidson, and published in the "Quart. Journ. of the Geological Society," Vol. xxvi., p. 70

SPECIES OF BRACHIOPODA FROM THE PEBBLES OF BUDLEIGH SALTERTON.

* Athyris (?) Budleighensis, *Dav. (?)*
* (?) erratica, *Dav.*
* incerta, *Dav. (?)*
Atrypa sp. (perhaps reticularis).
Chonetes sp.
* Crania transversa, *Dav.*
* Discina (?) Edgelli, *Dav.*
* incerta, *Dav. (?)*
* (?) Vicaryi, *Dav.*
† Lingula Hawkei, *Rouault.*
† Lesueuri, *Rouault.*
† Rouaulti, *Salter.*
* (?) Salteri, *Dav.*
* Nucleospira Vicaryi, *Dav.*
† Orthis Berthoisi, *Rou.* (?) var. erratica, *Dav.*
* pulvinata, *Salter.*
† redux, *Barr.* (?) var. Budleighensis, *Dav.*
* Valpyana, *Dav.*
* Vicaryi, *Dav.*
* Productus Vicaryi, *Salter.*
† Rhynchonella elliptica, *Schnurr* (?)
† inaurita, *Sandb.*
* (?) ovalis, *Dav.*
* Valypana, *Dav.*
* Vicaryi, *Dav.*
sp. (?)
† Spirifera macroptera var. microptera, *Goldf.*
octoplicata, Sow., or S. elevata, *Dalm* (?)
† Veruenilii, *Murch.*
Streptorhynchus crenistria, *Phill.*
* Strophomena Budleighensis, (?) *Dav.*
* Edgelliana, *Dav.*
* Etheridgii, *Dav.*
* Rouaulti, *Dav.*
* Vicaryi, (?) *Dav.*
sp.
Terebratula (?) sp. (?)

Though it was at one time thought that the Budleigh Salterton pebbles were of Lower Silurian age, and derived from the Armorican Grits of Brittany, Mr. Etheridge is of opinion that they are chiefly of Middle Devonian age, with an admixture of a few from Silurian and a few from Carboniferous rocks, and that all have been derived from localities in the British area, and at no great distance from the place at which we now find them.

* New species. † Species found out of British area.

FAMILIES.

(See Table II.)

Calceolidæ. One species.

Calceola.

Calceola cannot be allied with any genus of Brachiopoda, and since we have but one species of this abnormal genus, the *Calceola sandalina*, Linn., of our Middle Devonian rocks, must be placed entirely alone, and allowed at present to constitute a separate family.

As before stated, however, it is doubtful whether Calceola should be retained in the class Brachiopoda, inasmuch as even the molluscan character of *C. sandalina* has not been fully ascertained. (See page 82.)

Craniadæ. Nineteen species.

Crania.

Craniadæ is a second family in which only one genus has been placed. It will suffice, therefore, to direct attention here to the observations on the characters and distribution of the genus Crania (page 83), which are equally applicable to the characters and distribution of the family Craniadæ.

Discinidæ. Thirty-two species.

Acrotreta.	*Orbiculoidea.*
Discina.	*Siphonotreta.*

The Discinidæ are patelliform, and have the valves unarticulated, like the Craniadæ, but, unlike that family, they attach themselves by means of a peduncle passing through a foramen in the ventral valve.

Through the labours of Mr. Hicks the range of this family is found to be from the Cambrian, the Lower Cambrian of Sedgwick, to the Recent. But though possessing this most extended range, the Discinidæ have but few representatives in any formation, and are quite without a representative in several. The maximum specific development appears to be in Wenlock strata, from which we have six species. Of these three are of the typical genus Discina, two of Orbiculoidea, and one of Siphonotreta. Of the four genera which we place in Discinidæ three do not range out of the Silurians, and the type genus, as it is the earliest so it is the latest of the family, and extends the range through Mesozoic and Cainozoic strata to the formations now in progress.

LINGULIDÆ. Forty-nine species.

Kutorgina.	*Obolella.*
Lingula.	*Obolus.*
Lingulella.	

The Lingulidæ are characterised by horney or calcareo-corneous shells, unarticulated, and sub-equivalve; and by the possession of a peduncle passing *between* the valves.

The range of Lingulidæ is similar to that of Discinidæ, though possibly it is even more extended, since *Lingulella ferruginea,* Salt., has been found in rocks much lower than those in which *Discina pileolus,* Hicks, first with certainty appears. The specific distribution of Lingulidæ differs considerably from that of Discinidæ, for while the maximum development of Discinidæ is in the Upper Silurians, the greatest number of species of Lingulidæ is to be found in our Lower Silurians. There is, however, one point of resemblance between the distribution of these two families that deserves notice, and that is that only the typical genus of each ranges above the Silurian rocks, and appears to have survived the close of the Silurian epoch.

ORTHIDÆ. One hundred and eight species.

Davidsonia.	*Orthisina.*
Leptæna.	*Streptorhynchus.*
Orthis.	*Strophomena.*

The distinctive characters of the Orthidæ, called sometimes the Strophomenidæ, can only be drawn from their fossilized shells, since all the genera of which the family is composed are extinct.

The valves are "plano-convex, or concavo-convex," with a *straight* hinge line, which may be longer than the width of the shell. The beak is not prominent in this family, and only sometimes foraminated. The shell structure is usually punctated, and the interior is without calcified brachial supports.

The Orthidæ would be essentially Palæozoic were it not for the fact that several species of the genus Leptæna occur in the Middle and Upper Lias. Should the Menevian group, as is not improbable, be ultimately excluded from the Silurian system of Murchison, the Orthidæ will be found to commence their range in Cambrian rocks, the *Orthis Hicksii*, Salt., having been obtained from the uppermost bed of the Menevians of South Wales. The range of the family would therefore be from the Cambrian to the Upper Lias. Orthidæ were especially abundant in the Silurian epoch, and appear to have attained their maximum specific development during the deposition of the Caradoc rocks, from which group of strata we have forty-nine species of the genera Orthis, Strophomena, and Leptæna. In the Devonians the *genera* increase by the addition of Streptorhynchus and Davidsonia, but the number of *species* is very much diminished, the Middle Devonian furnishing not more than eleven species of Orthidæ. Eight species appear in the Carboniferous Limestone, two in the Millstone Grit, and only one in the uppermost of the Palæozoic formations, the Permian. The four species of Leptæna in the Lias, so far as we yet know, are the only representatives of this important family in Mesozoic strata.

PRODUCTIDÆ. Seventy-one species.

Chonetes. *Strophalosa.*
Productus.

In many respects the Productidæ resemble the Orthidæ. The hinge line is straight, or nearly so, the valves are concavo-convex and sometimes articulated, but they are unlike in having the exterior furnished with tubular spines. The vascular and muscular impressions in the interior of the valves differ considerably from those in the Orthidæ.

Productidæ is an extinct family, and confined to the Palæozoic rocks, the stratigraphical range extending only from the Upper Llandovery to the Permian. The distribution of the species is very remarkable. Few species of Productidæ are found in strata older than the rocks of the Carboniferous epoch, and few species in strata newer than those rocks. But in the Carboniferous Limestone there is an enormous specific development of the family, fifty-seven species occuring in that formation in the British Islands.

RHYNCHONELLIDÆ. One hundred and twenty-three species.

Camarophoria.	*Rhynchonella.*
Eichwaldia.	*Stricklandinia.*
Pentamerus.	*Triplesia.*
Porambonites.	

The Rhynchonellidæ are globose, ovoid, or trigonal brachiopods, having beaks foraminated *under* the apex. The shell is usually plicated, and is impunctate and fibrous in structure. The valves are articulated, and the hinge-line not straight. There is no interior loop, but a septum, and oral lamellæ characterise the dorsal valve.

The range in time of the Rhynchonellidæ extends from the Lower Silurian to the present epoch, and a great specific development is found in Silurian, Devonian, Carboniferous, Jurassic, and Cretaceous strata. In the Inferior Oolite we find the maximum specific development, since from this formation twenty-five species have been derived, and the whole of these are species of the typical genus Rhynchonella. The formations which yield representatives of this family most abundantly are the Wenlock, fifteen species; the Middle Devonian, seventeen; the Carboniferous Limestone, eighteen; the Middle Lias, fourteen; and the Inferior Oolite, twenty-five; while the Lower Greensand gives us nine, and the Upper Greensand and the Chalk eleven each.

The *Rhynchonella psittacea*, Lam., is the only representative of the family as yet found in our Tertiary strata, and this species is still living in British waters. Three other recent species of the same genus have been described.

As with the Discinidæ and the Lingulidæ, so with the Rhynchonellidæ, only the typical genus of the family passes up into Mesozoic and Cainozoic strata, all the other genera being essentially Palæozoic.

SPIRIFERIDÆ. One hundred and twenty-five species.

Athyris.	*Retzia.*
Atrypa.	*Spirifera.*
Cyrtia.	*Spiriferina.*
Cyrtina.	*Suessia.*
Merista.	*Syringothyris.*
Meristella.	*Uncites.*
Nucleospira.	

Perhaps the only structural character peculiar to the Spiriferidæ that can be considered permanent, is the possession of an apophysiary system, consisting of two calcified spiral processes. These internal spires (from which the name Spirifera is taken), form, however, a distinguishing feature, very marked and distinct, and they very effectually separate the Spiriferidæ from the other families of the Brachiopoda. The stratigraphical range of the Spiriferidæ is similar to that of the Orthidæ, inasmuch as it commences in the Lower Silurian and extends upwards no further than Lower Jurassic strata, but the distribution of the species of the two families is very dissimilar. In the Orthidæ we find the maximum specific development in the Caradoc rocks, while that of the Speriferidæ is conspicuously in the Carboniferous Limestone, and only four species appear in Caradoc strata. A very considerable development of Spiriferidæ is found in the Upper Silurians, one formation of which, the Wenlock, provides our lists with twenty-one species of seven genera of the family. Again in Devonian rocks we have a great development, greater indeed than in the Upper Silurians, and not only specifically so, but also generically, for we have eight genera represented by thirty-three species in the Middle Devonian.

But in Carboniferous strata we find no less than nine genera of Spiriferidæ represented by forty-nine species in the Carboniferous Limestone. The punctated genus Spiriferina, carries the range to the Inferior Oolite, in which *Spiriferina Oolitica,* Moore, appears as the latest British representative of the important family, Spiriferidæ.

TEREBRATULIDÆ. One hundred and twenty-six species.

Argiope.	*Terebratula.*
Magas.	*Terebratulina.*
Megerlia.	*Terebrirostra.*
Reusseleria.	*Trigonosemus.*
Stringocephalus.	*Waldheimia.*
Terebratella.	*Zellania.*

This great family, which may, perhaps, not altogether improperly be called the principal family of the Brachiopoda, is well characterized both exteriorly and interiorly. The form of the shell varies very much, yet the ventral valve is provided with a beak having an apical foramen. The valves are articulated, and the shell structure is punctate. In the dorsal valve a calcareous loop, sometimes simple sometimes reflected, sometimes small sometimes large, and variously attached, is an important characteristic; for on the variations of form, size, and attachment of the loop, the differentiation of the various genera of Terebratulidæ in a great measure depend.

Our earliest representatives of this family occur in Middle Devonian strata, and the range in time of the Terebratulidæ extends from that epoch to the present. The number of species in Palæozoic rocks is very small, but in Lower Mesozoic strata we find a great increase, and from the Inferior Oolite we obtain the maximum number, thirty-one. A great development is also observable in Cretaceous rocks, the Lower Greensand giving us twenty-seven, the Upper Greensand fifteen, and the Chalk twenty species of Terebratulidæ. Though the greatest number of species have been found in the Inferior Oolite, the greatest number of genera occur in Upper Cretaceous strata. It is worthy of note that the Terebratulidæ is the only family of the Brachiopoda of which several genera are still living. These are in addition to the typical genus Terebratula, Argiope, Megerlia, Terebratella, Terebratulina, and Waldheimia.

THECIDEIDÆ. Fifteen species.

Thecidium.

Though the genus Thecidium, as has previously been stated, possesses several characters in common with the Terebratulidæ, and though it has been placed in that family by some authors, the markedly distinct mode of attachment of the animal to the rocks, and the consequent absence of a peduncle as well as the very thick and peculiar shell, appear to separate Thecidium from the Terebratulidæ, and to constitute a sufficient basis whereon to found a family.

Since, as in the case of Craniadæ, the range of the genus is the range of the family, it will only be necessary to refer to the remarks on the range and specific distribution of Thecidium, page 101.

CLASS.

(See Table IV.)

When we pass from the consideration of the range of genera and families, and of the distribution of species of each genus and each family, and direct our attention to the specific representation of the Class Brachiopoda in each formation, in each system, and in each great division of the stratified rocks of the British Islands, we find the results indicated by the diagrammatic table, Table IV.

The range is in this table shown to be from the Cambrian to the Recent, with the maximum specific development in the Carboniferous Limestone. But when we compare systems we shall find a greater number of species in the Silurian than in any other. Of the three great divisions of the stratified rocks—the Palœozoic, the Mesozoic, and the Cainozoic—the first, the Palœozoic, contains by far the greater number of species, though, as compared with the Cainozoic deposits, the Mesozoic rocks indicate a very large development of Brachiopoda.

Our Cambrian rocks give us three genera and four species, but if we include the Menevian group in the Cambrian we shall be able to record, chiefly through the labours of Mr. Hicks, the occurrence of four genera and six species in these our oldest, so far as we yet know, fossil-bearing rocks.

The Class rapidly increases in importance, and the Lower Silurians yield a very large number of species. The Primordial Silurian, 12; Llandeilo, 27; Caradoc, 73; and the Lower Llandovery, 39 species. In the Upper Silurians we find an increase on these numbers, the Upper Llandovery showing 48; the Wenlock, 81; and the Ludlow, 40.

There is a very large development in our Devonian rocks, though not so great as in the Upper Silurians. From Lower Devonian strata we derive 31 species, from Middle Devonian 71, and from Upper Devonian 39 species.

An enormous increase is now apparent, since in the Carboniferous Limestone we have the great number of 147 species, which is, as before stated, the maximum number. The good work which has been done by Mr. D. C. Davies, of Oswestry, on the North Wales Border, and by other explorers of the Millstone Grit, enables me to enumerate fourteen species as occurring in that formation. In the uppermost member of the Palœozoic division, the Permian, we find 21 species.

It will be observed, when attention is paid to the number of species in the successive Palœozoic formations, that there is an alternate increase and decrease. Now this increase and decrease will be found to correspond in a great measure with the pelagic or deep sea, and the comparatively shallow water character of the respective groups of strata.

Passing to Secondary strata, and including the Rhœtic series in the Trias, we find one species in the strata below the Lias. A great development is observable in the Lower Jurassic rocks, notably in the Inferior Oolite, and chiefly of the genera Rhynchonella and Terebratula. Of the three divisions of the Lias, the Middle contains the largest number of species of Brachiopoda, the Lower giving 23, the Middle 51, and the Upper 32. The large number of 71 species occurs in the Inferior Oolite, above which formation a great decrease is conspicuous, and this decrease continues through the Middle and Upper Oolites until we reach the Portland Oolite, in which we have only a single very doubtful occurrence of a Brachiopod.

We perceive a very considerable development in Cretaceous strata, the Lower Greensand containing 40 species, the Upper Greensand 27, and the Chalk series, including the Chloritic Marl, 34. Only five species appear in the Gault, though this formation is by no means barren of other forms of marine life.

We now reach Cainozoic strata, and there find a remarkable scarcity of Brachiopoda, not more than nine species having been described from the entire series of our Tertiary deposits. Of these two are in the Lower Eocene, two in the Middle Eocene, six in Older Pliocene or Crag, and one only in our most recent or Newer Pliocene deposits.

Although Brachiopoda are found in our oldest fossiliferous rocks, and in our newest deposits, and very abundantly in many formations, there are yet several so-called formations which are apparently barren of Brachiopoda. Of these the Bunter and the Keuper are devoid of all remains of Mollusca, so far as has yet been ascertained. The Purbeck, the Wealden, and the Upper Eocene are chiefly fluviatile and estuarine, and the Miocene* is represented by leaf-beds and lignites in the British Islands. We, therefore, do not expect to find in these formations such exclusively marine species as are the Brachiopoda. The Portlandian rocks, however, do not indicate conditions that would be unfavourable to the existence of Brachiopoda, and yet, with the exception of the very doubtful occurrence of *Waldheimia rex*, the Portland Oolites are without a Brachiopod.

Though "the testimony of the rocks" of the British Islands would appear to indicate the approaching extinction of the Brachiopoda, we have but to remember that between eighty and ninety species of recent Brachiopoda have been described, and that in some seas some of these species are represented very abundantly, to perceive that it is most unsafe to generalise from the results of the exploration of a limited area.

Nor is it unreasonable to suppose that with the return of similar conditions we might have a specific development equal to that which existed in the past. It is probable that in the beds of some of the seas of the globe, even at the present day, Brachiopods are

* The Tertiary beds of Malta, considered to be of Miocene age, contain *Terebratula ampulla*.

;ombed as numerously and as thickly as when our Lias or ior Oolite was in process of formation. And, indeed, the ɜep sea dredgings by Dr. Carpenter, Professor Wyville n, and Mr. Gwyn Jeffreys, would almost afford sufficient that this is more than probable.

Brachiopods are found to flourish in very various climates ıters of very various depths. British recent Brachiopods and found chiefly off the coasts of Scotland, the seas of the being the waters from which the greater number of ɜ have been obtained. The species found living in ɪeas are *Argiope cistellula*, S. Wood, *Rhynchonella psit-* emintz, and *Terebratulina caput-serpentis*, Linnæus.

llowing Table shows the number of species of Brachiopoda in each "formation" of British strata, with the prevailing d genus:—

TABLE III.

nations.	Species	Prevailing Families.	Prevailing Genera.
	4	Lingulidæ	Lingulella
ilurian	12	Lingulidæ	Lingulella
	27	Orthidæ	Orthis
	74	Orthidæ	Orthis
overy	39	Orthidæ	Orthis
overy	48	Orthidæ	Orthis
	81	Orthidæ	Orthis
	40	Orthidæ	Lingula and Orthis
ıian	31	Spiriferidæ	Spirifera
nian	71	Spiriferidæ	Rhynchonella and Spirifera
ıian	39	Spiriferidæ	Spirifera
s Limestone	147	Productidæ	Productus
it	14	Productidæ	Productus
	21	Spiriferidæ	Spirifera
	1	Discinidæ	Discina
	23	Terebratulidæ	Rhynchonella
	51	Terebratulidæ	Rhynchonella
	32	Rhynchonellidæ	Rhynchonella
te	71	Terebratulidæ	Rhynchonella
	20	Terebratulidæ	Terebratula
tc.	17	Terebratulidæ	Terebratula
	15	Terebratulidæ	Terebratula
lite	12	Terebratulidæ	Terebratula and Thecidium
Clay	5	Discinidæ and Rhynchonellidæ	Rhynchonella
ite	(??)	(??) Terebratulidæ	(??) Waldheimia
sand	40	Terebratulidæ	Terebratula
	5	Terebratulidæ	Terebratula
sand	27	Terebratulidæ	Rhynchonella
	34	Terebratulidæ	Rhynchonella
.e	2	Lingulidæ	Lingula
ne	2	Terebratulidæ	Terebratullina
ıe	6	Terebratulidæ	Terebratula
ne	1	Rhynchonellidæ	Rhynchonella

A few words may, perhaps, be added with reference diagrammatic tables. They are the first of the kind which as I know, have been constructed, and they are given to striking, and yet accurate manner, the range, increment, de maximum development, and relative numerical importance specific representation of each family, as well as of the Brachiopoda in British strata. They require little explanation those accustomed to palæontological tables, as the arrangement very simple. Each short vertical line indicating the occurrence of one species, the number of species of any family, or of the in any formation, can be readily ascertained; and the symmetrical arrangement of these lines renders the increment and decrement each family and of the class very apparent.

In the early part of this paper I stated how greatly I was debted to the researches of Mr. Davidson, and everyone acquainted with his magnificent works will pardon me, before concluding, referring to that gentleman's labours as being of the greatest possible value to me; and I must add my special and personal thanks to Mr. Davidson for the interest he has expressed in work, and for his generous desire to see this paper published.

EACH FAMILY OF BRACHIOPODA.

on the Globe.

*	*	

ANNUAL GENERAL MEETING, 3rd February, 1871.

Professor Morris, F.G.S., President, in the Chair.

The following Report of the General Committee for the year 1870 was read by the Honorary Secretary:—

The proceedings of the Association during the past year have been marked by the excellence of the Papers read at the ordinary meetings of the members; by the number and success of the excursions made to places of geological interest, and by the visits to public museums.

The following papers were read during the year :—

On Graptolites, by W. Carruthers, F.L.S., F.G.S.
On the Strata exposed by the Line of Railroad through the Sevenoaks Tunnel, by C. Evans, F.G.S.
On Volcanoes, by H. Woodward, F.G.S.
On the Chalk of the Isle of Thanet, by G. Dowker, F.G.S.
Notes on the Geology of the Neighbourhood of Swanage, by T. D. Bott, F.G.S.
On a Visit to the Scilly Isles, by C. T. Richardson, M.D.
Two Days in a Mining District, by J. L. Lobley, F.G.S.
On the Distribution of the British Fossil Brachiopoda, by J. L. Lobley, F.G.S.
On the Structural Character of the Dinosauria, by Dr. J. Murie, F.G.S.
Remarks on the Geological Distribution of the Dinosauria, by Professor J. Morris, F.G.S.
The British Islands, Past and Present, by R. Etheridge, F.G.S., F.R.S.E.
On the Geology of the Neighourhood of Portsmouth, by C. Evans, F.G.S.

These papers, several of which, as will be observed, were by geologists of eminence, fully maintained the reputation of our monthly meetings. The subjects chosen, and the manner in which they were handled, were in each instance well adapted to the character and purpose of the Association, and several of the papers were of a superior order. Your Committee rejoice to be able to add that some of the most elaborate and able of them were written by members of the Association; at the same time they may be permitted to again urge upon members, and particularly upon the younger members, the desirableness of their taking a larger share in this part of the work. It is not to be wished that all the papers should be of an elaborate description, deal with large subjects or leading principles, or occupy the greater part of an evening in the reading. But with papers such as are named in the above list, it would be well if we could occasionally have short papers giving a clear and succinct account of some special investigation, or original piece of field-work, undertaken by our younger members: papers in which they might try their nascent skill, and dip their wings for a bolder flight. Such papers could not but be of service to the writers, and they would lead to discussions which would add to their interest to the members generally.

It might be necessary to introduce these papers with some reserve, and occasionally to exercise the previous censorship with seeming severity; but it deserves a consideration whether an evening might not be occasionally appropriated, especially to the reading of three or four such papers.

Your Committee note with pleasure the general animation of the discussions which follow the reading of the papers; but here again they earnestly invite the wider co-operation of the members and friends. A suggestive remark, however brief, any item of local information—often a mere question—will serve not only to enliven the proceedings, and evince interest and sympathy, but frequently elicit knowledge of a kind that would hardly have been brought forward in a more formal manner. The object of these, as of the former remarks, is by this, or any means, to induce as many of the members as possible to take part in the actual work of the Association.

Before passing to another section of the Report, your Committee wish to offer a few observations on their recent publications. Among the interesting papers communicated to the Association during this and the preceding year, have been some directly bearing on Palæontology, and having for their object a concise description and classification of certain groups of fossil remains. Of these, the papers on the *Cephalopoda*, by the Rev. T. Wiltshire, and on the *Palæozoic Bivalved Entomostraca*, by Professor T. Rupert Jones, have been distributed among the members; and those read by Mr. W. Carruthers, on *Graptolites*, and by Mr. J. Logan Lobley, on *Brachiopods*, are in preparation with a view to their early issue. The value of these papers to the student of Geology cannot but be fully appreciated; and your Committee hope, with the kindly co-operation of members and friends, that a continuation of similar papers will be prepared for, and published by, the Association, that thus one of its main objects may be carried out—the diffusion, among its members and others, of useful information, especially with reference to the character and relations of fossil remains to existing forms, and so to assist the student in inferring the conditions under which the various strata were accumulated.

The valuable papers "On the Chalk of the Isle of Thanet," by Mr. Dowker, and "On some Chalk Sections between Croydon and Oxtead," by Mr. C. Evans, have been printed and distributed among the members. These papers shewing subdivisions, or zones, in the chalk formation, are of much interest in relation to the origin and mode of accumulation of this deposit; more especially at the present time, when the recent discoveries of the deep sea deposits, now taking place in the bed of the Atlantic, bear certain analogies to, or contain forms which are considered to be representatives of those found in the older cretaceous formation.

The excursions have become an increasingly prominent feature in the proceedings of the Association. Their value to the student every geologist will admit. Geology must be learned in the field. Whatever may be acquired from books or in the lecture-room must be applied there: and these excursions, made under the guidance of experienced geologists, not only afford ready means of testing, and turning to account, what has been studied at home, and of occasionally collecting characteristic rocks and fossils, but also furnish excellent lessons in the art of observing and recording observations, and, what is not least to be prized, opportunities for social intercourse, and mutual aid and recognition as fellow-students in a science in which co-operation is especially valuable.

Excursions were made during the year to—

Caterham and Oxtead, Surrey, under the guidance of Mr. C. Evans, F.G.S.; and to Nutfield, Surrey, under the guidance of Mr. C. J. A. Meÿer, F.G.S.

In Kent to Herne Bay, on Whit Monday, under the direction of Professor Morris; to Lewisham, and to Erith.

In Hertfordshire, Watford was visited under the guidance of Mr. J. Hopkinson, F.G.S.; and in Middlesex, Hampstead, where Mr. S. R. Pattison, F.G.S., kindly volunteered to lead, and where, at the conclusion of the day, the members were hospitably entertained by Mr. C. Evans, and had the opportunity afforded them of examining his extensive collection of Tertiary and Cretaceous fossils.

An afternoon was pleasantly and profitably spent at Grays, in Essex, where, with Professor Morris as guide, the extensive chalk quarries were carefully examined, and afterwards the party were liberally entertained by R. Meeson, Esq., F.G.S., in his picturesque grounds immediately above the quarries.

More distant excursions were made under the able direction of Professor Morris, in May, to Swindon, Stroud, and May Hill, a very instructive three days' trip, and to Aylesbury, in Buckinghamshire.

These excursions were all well, and some numerously, attended, and those who took part in them invariably expressed their satisfaction with the result, and their enjoyment of the meeting. Their popularity and success must again be to a great extent ascribed to the zeal and kindness of the President, who, this year, as in the preceding, gave up a large amount of time to their arrangement and conduct. Your Committee also desire to express their obligations to the other gentlemen who led excursion parties.

Besides the country excursions, visits were made on three or four occasions to the British Museum, and to the Museum of Practical Geology. At both of these places there was a very numerous gathering of members, who evinced great interest in the proceedings. At the British Museum, addresses were given before the actual specimens by Professor Morris, Professor Tennant, Mr. H. Woodward, Mr. Carruthers, and Dr. Carter Blake; at Jermyn-street, the members were conducted round the galleries by Mr. Etheridge, Professor Morris, and Professor Tennant, who pointed out the principal objects of interest and delivered brief addresses. To the officers of both these institutions the Committee are under great obligations for the frank and friendly cordiality with which they tendered their assistance.

The success of these visits, and the many enquiries which have been made respecting their repetition, seem to suggest the desirability of making a new series of such visits to these and other great public collections, especially as they may be made at a season when country excursions are impracticable. But both the excursions and the visits to the Museums seem to your Committee to be worthy of all possible encouragement: and they recommend to consideration the possibility of re-arranging them so as to extend their usefulness, and place them for the future on a more regular and systematic basis.

With this view they invite such members as may be qualified by general or special knowledge, and any friends who may possess local information, to volunteer their assistance in arranging and conducting excursions.

Your Committee have to record, with exceeding regret, the loss by death of one of the vice-presidents. Mr. E. Cresy was one of the founders of the Association; was one of the small band who took part in the Conference, Nov. 29, 1858, at which the Association was formally constituted; was one of the members of the original Committee, and one of the most regular attendants ever since; was President in 1864-65, and then Vice-President until his death: and in each capacity, by his wide and various knowledge, energy, readiness of resource, urbanity, and business tact, rendered great service to the Association at every stage of its career. He contributed several valuable papers; and was ever ready to assist the officers of the Association with advice and good counsel.

In turning to the appointment of the Officers of the Association for the year 1871, your Committee, in announcing the retirement, by efflux of time, of the President, Professor Morris, who has already served one year more than the usual period, have to repeat the deep obligation which they, and the whole body of members, feel for the many and great services he has rendered to the Association during his tenure of office. They trust, however, that, as Vice-President, he will continue to afford them his invaluable aid and counsel.

As President for 1871 and 1872, the Committee have nominated the Rev. T. Wiltshire, M.A., F.G.S., who has kindly expressed his readiness to accept the post. Mr. Wiltshire, they may remind the members, was one of the founders of the Association; was Chairman of the Conference for its establishment, and virtually the first President, Mr. Toulmin Smith, originally elected to that post, having resigned after the first meeting, in January, 1859. Mr. Wiltshire acted as President during 1859-1861, and was then elected Vice-President. He has always been an active member of the Committee; has contributed several valuable papers, some of which have been printed, and has conducted many of our excursions.

The members will participate in the regret with which the Committee announce the retirement of Mr. John Cumming, F.G.S., from the post of Honorary Secretary. Mr. Cumming has filled this office since 1861 with great benefit to the Association, and now resigns it on account of the increase of his professional avocations no longer allowing him to devote to it the time he feels to be necessary to the adequate fulfilment of its duties. As a testimony of their sense of the value of his services, and their regret at his retirement, your Committee recommend his election as Vice-President, and they trust to have in that capacity the benefit of his frequent presence and counsel at their meetings.

As his successor in the office of Honorary Secretary, they beg to recommend Mr. J. Logan Lobley, who has intimated his willingness to serve, and whose energy and experience, they believe, will be of essential service to the Institution.

The Financial Condition of your Association continues to offer matter for congratulation. There has been an increase in the annual subscriptions; the general expenses have been very moderate; the expenditure for printing has been not nearly so heavy as 1869; and, as the result, the balance remaining in hand, after discharging all liabilities, has increased to the sum of £58. Messrs. Caleb Evans, F.G.S., and Mr. M. Hawkins Johnson, have kindly acted as Auditors; your Committee append their Report, and recommend these gentlemen for election as members of the Committee in the place of Mr. J. Pickering, who, after working with us zealously from the commencement, retires on account of the state of his health, and of Mr. J. Logan Lobley, who has accepted the office of Honorary Secretary. The other members of the Committee and Officers of the Association submit themselves for re-election.

Your Committee recommend the following list of officers for the year 1871:—

President.—Rev. T. Wiltshire, M.A., F.G.S., F.R.A.S., &c.

Vice-Presidents.—Professor John Morris, F.G.S.; James Thorne, F.S.A.; Professor J. Tennant, F.G.S., F.R.G.S., &c.; John Cumming, F.G.S.

Treasurer.—W. Hislop, F.R.A.S., 177, St. John Street Road, E.C.

General Committee:

J. W. Bailey.	W. H. Leighton, F.G.S.
Rev. J. Crombie, M.A., F.G.S.	T. Lovick.
C. Evans, F.G.S.	C. J. A. Meyer, F.G.S.
J. Hopkinson, F.G.S., F.R.M.S.	G. Potter, F.R.M.S
J. W. Ilott.	C. T. Richardson, M.D.
M. H. Johnson, F.G.S	H. Woodward, F.G.S., F.Z.S.

Honorary Secretary.—J. Logan Lobley, F.G.S., F.R.G.S., 50, Lansdowne Road, Kensington Park, W.

Honorary Librarian.—A. Bott, A.A., F.G.S.

Your Committee also recommend the election of THOMAS DAVIDSON, Esq., F.R.S., F.G.S., &c., and CHARLES MOORE, Esq., F.G.S., &c., as *Honorary Members* of the Association.

The Auditors' report is on the next page.

The above Report having been adopted, and the Officers and Honorary Members therein recommended duly elected, it was unanimously resolved "That the best thanks of the Association be given to John Cumming, Esq., F.G.S., for his services during the time he has acted as Secretary; and to Professor Morris and the other members of the General Committee for their services during the past year."

The Annual General Meeting was concluded by Professor Morris vacating the chair, which was then occupied by the newly-elected President, the Rev. Thomas Wiltshire, M.A., F.G.S., F.R.A.S., &c., when the Ordinary Meeting for February was commenced.

BALANCE SHEET OF RECEIPTS AND DISBURSEMENTS.

Dr.	£	s.	d.	Cr.	£	s.	d.
By Balance	41	0	0	To Printing	23	16	9
,, Annual Subscription and Entrance Fees ...	64	10	0	,, Engraving...	2	5	0
,, Interest on Stock	8	16	0	,, Bookbinding	1	5	9
				,, Gas and Attendance	5	12	6
				,, Collector's Commission...	1	1	6
				,, Postage, Stationery, Porterage, &c.... ...	17	2	0
				Balance	58	2	6
	£109	6	0		£109	6	0

We have this day examined the Accounts of the Treasurer of this Association, and find a balance of £58 2s. 6d. in his hands.

(*Signed*) C. EVANS, M. HAWKINS JOHNSON, } *Auditors.*

January 27th, 1871.

ORDINARY MEETING, 3rd February, 1871.

The Rev. T. Wiltshire, M.A., F.G.S., &c., President, in the Chair.

The following donations were announced:—

"Abstract of Proceedings of the Geological Society," from that Society.

"Journal of the London Institution," from that Institution.

"On a New Genus of Graptolites," by John Hopkinson, Esq., F.G.S., F.R.M.S., from the Author.

The following were elected Members of the Association:— Robert Davies Roberts, Esq., and Ernest Swain, Esq.

The following paper was read:—

"On the Geology of the Neighbourhood of Portsmouth and Ryde." Part II.

By Caleb Evans, Esq., F.G.S.

Middle Eocene.—The line of separation between the Lower and the Middle Eocene is usually drawn at the top of the London Clay. All divisions made in a nearly continuous series of deposits must be more or less artificial in character, and it may be questioned whether a more natural subdivision would not be made if the bed of sand next to be noticed, and generally known as the Lower Bagshot Sand, were included in the Lower Eocene division, and the separation were made at the thick deposit of rounded pebbles which follows.

The recurrence of beds of pebbles at intervals is a very conspicuous feature in the Hampshire Tertiaries and is one of considerable importance, since the increased transporting power, which the presence of these pebbles denotes, probably resulted from important changes in the physical geography of the area over which they were dispersed. The whole of the period during which the Lower and Middle Eocene strata were deposited appears to have been one of gradual depression, which took place in general at a rate so slow that it was neutralised by the deposit of sediment, since throughout a thickness of more than 1500 feet shells characteristic of shallow water prevail, and at several levels occupy the position in which they lived. At intervals more rapid depressions appear to have taken place, resulting in the removal of the shingle from the old shores of the Eocene Sea, and the scattering of the pebbles over the sea bed.

In the Lower Eocene deposits of Portsmouth and Whitecliff Bay there are three repetitions of these conditions of deposit. The pebble bed above the Mottled Clay is succeeded by a thick deposit of clay, and then by a water-bearing sand. Another pebble bed separates these beds from a similar succession of clay and argillaceous sands, above which is the conspicuous pebble bed seen in the Dockyard excavations, and also in Whitecliff Bay. The third series of deposits is incomplete so long as the division between the Lower and the Middle Eocene is made immediately above the clay which follows this pebble bed, but it is completed if the superimposed sands are associated with the clay below rather than with the next pebble bed above; and the great thickness of this last pebble bed, where it is seen in Whitecliff Bay, must indicate a greater change of physical conditions, and perhaps a greater interval of time, than the lower ones denote. Accordingly, we find that the rich fauna, met with in the beds that follow it, is very distinct from that of the lower beds.

The division between the Lower and the Middle Eocene is no less artificial in the London area, where the London Clay, with a bed of pebbles at its base, is also succeeded by or gradually passes into sands.

These sands have hitherto been considered as the lowest portion of the Middle Eocene division, and the fact that the supposed equivalents of these beds in France and Belgium contain *Nummulina planulata* is favourable to this classification, as the Nummulite group is abundant throughout the strata of Middle Eocene age, but has not been met with in the Lower division.

In the English Tertiary areas the Middle Eocene strata (including the sands above alluded to) have also been distinguished as the Bagshot Sands, because beds of this age, mostly arenaceous in character, occupy a considerable tract of country on and around Bagshot Heath in Surrey. They have been subdivided into a Lower, Middle, and Upper series.

In Whitecliff Bay the Lower Bagshot group is represented by the beds intervening between the Bognor Series, the details of which have already been given, and a pebble bed 18 inches thick. They may be described as pale grey or greenish sands, with thin laminæ of pipe clay, separated by a band of ferruginous sandstone from yellow and white micaceous sands.* The thickness of the group is about 135 feet. No fossils are recorded from these sands.

It is difficult to determine to what extent the remarkable series of variegated sands and clays, 772 feet in thickness, which forms so striking and beautiful a feature in the cliffs of Alum Bay, corresponds with the Lower Bagshot group as represented in Whitecliff Bay, as in Alum Bay the pebble beds are not so clearly seen as in Whitecliff Bay, and the only organic remains met with consist of beautiful impressions of leaves (found in a single bed of white clay) and four or five remarkable layers of lignite, which are present in the upper part of the group of variegated beds. These lignite beds, according to Mr. Bristow, are each "based upon a stratum of clay, containing, apparently, the rootlets of plants, as in the underclay of the true coal measures."†

Beds of pipeclay, containing impressions of leaves, are exposed at Bournemouth, and near Corfe Castle, and are probably of nearly the same age as the Alum Bay leaf bed.

The Lower Bagshot Sands are not clearly seen at the surface in the neighbourhood of Portsmouth, but there can be little doubt that these beds are there present, since the interval taken in the line of the dip of the beds between the dockyard sections and the nearest point at Southsea, where a clearly defined bed of the Bracklesham or Middle Bagshot series appears at the surface, would denote the presence of 250 or 300 feet of strata. This conclusion is based on the assumption that the Tertiary strata near Portsmouth have an uniform dip of about 1 in 22.

The Lower Bagshot beds retain the same mineral character over a considerable area in the south of England, and can be identified without difficulty in the London district. The general description of these sands as they appear in Whitecliff Bay, applies, with a few minor variations, equally to the sands that cap the London Clay at Hampstead Heath.

In the neighbourhood of Bagshot these sands occupy a considerable surface, and have been described by Mr. Prestwich‡ as light-coloured siliceous sands, with a few thin subordinate argillaceous beds, and a very few concretionary blocks of hard siliceous sandstone, the whole being about 130 feet in thickness.

* Bristow—Mem. Geological Survey.
† Mem. Geological Survey, Isle of Wight, p. 43.
‡ Quart. Jour. Geo. Soc., vols. 3 & 11.

Outliers—the result of the large amount of denudation to which the London area has been subjected—have been observed at Harrow, Hampstead, Epping, Southend, and Sheppey.

In the London, as in the Hampshire district, the only organic remains met with in the Lower Bagshot Sands are the impressions of plants.

The foreign equivalents of these beds exhibit a gradual passage from these barren sands to highly fossiliferous shell beds.

In Belgium and Northern France the Lower Bagshot beds are represented by about* 100 or 120 feet of siliceous sands between the representative of the Calcaire Grossier and the eastern extension of the London Clay. These beds are seen in this position in the Hill of Cassel, thirty-five miles E.S.E. of Calais. In Belgium, at Lille, and to the eastward, this zone is characterised by the presence of *Nummulina planulata*, a fossil which also occurs in great abundance in certain shelly beds of the Paris basin, known as the "Lits Coquilliers." These last named beds are about† 20 feet thick, and abound with well preserved fossils, and rest on light yellow and greenish quartzose sands, about 140 feet thick. Of the 18 species found at Cassel, 15 or 16 belong to the Lits Coquilliers.

The Nummulite family have a wide geographical range, but in time they appear to especially characterise the Middle Eocene period, and three species, *Nummulina variolaria*, *N. lævigata*, and *N. planulata*, appear to be respectively characteristic of the Upper, the Middle, and the Lower subdivisions of the strata of that epoch in Belgium, in France, and in Italy. *Nummulina planulata* is not recorded from English strata, but the first two species above named occupy well marked positions in the Hampshire series.

Mr. Prestwich observes of the Lits Coquilliers that‡ "they seem as much or even more in regular sequence with the underlying than with the overlying series." And that "many species of the shells which had passed from the lower marine sands into the London Clay, or had migrated to some adjacent district, reappear in the Lits Coquilliers, but few of them had their existence prolonged to the period of the Calcaire Grossier."

In these respects the Lits Coquilliers appear to occupy—as the

* Lyell—Quart. Journ. Geo. Soc., vol. 8.
† Prestwich—Quart. Jour. Geo. Soc., vol. 11.
‡ Quart. Journ. Geo. Soc., vol. 11.

Lower Bagshot Sands possibly do in England—an intermediate position between the Lower and the Middle Eocene deposits.

Middle Bagshot or Bracklesham Series.—The Hampshire representatives of the Middle Bagshot group are also termed the Bracklesham Series, as beds of this age have been studied at, and a rich collection of fossils obtained from Bracklesham Bay, about seven miles south of Chichester. It is only on rare occasions that the Bracklesham Series can be well seen at this place, as the bay is destitute of cliffs, and the beds are only exposed at intervals along the shore between the tide marks. No other Eocene deposits are there seen, but in Whitecliff Bay the relation of the series to the beds both above and below can be well studied on the shore and in the cliffs.

A very valuable paper on the Bracklesham Series has been published by the Rev. Osmond Fisher in the 18th vol. of the Quarterly Journal of the Geological Society.

The lowest bed of the Bracklesham Series in Whitecliff Bay, according to Mr. Fisher, is the highest of the beds of pebbles already mentioned, which is from 10 inches to 18 inches in thickness. The whole group consists of alternations of sand and sandy clay, and is about 660 feet thick. There is much vegetable matter in many of the beds, and Mr. Fisher has distinguished nine principal fossil-bearing beds, which he has placed in four groups. The highest group, A, abounding with Gasteropoda, and the next group B, containing the large *Cerithium giganteum,* are together about 281 feet thick, and are characterised by the presence of *Nummulina variolaria,* which is especially abundant in one of the higher beds of the series. Group C is distinguished by the abundance of *Nummulina lævigata,* and group D by the presence of *Cardita acuticosta,* and *Cypræa tuberculosa.* These two groups are about 360 feet thick.

The Nummulites may be obtained in considerable numbers, and several beds contain in great abundance *Cardita planicosta* and *Turritella imbricataria,* together with other fossils.

The richness of the Bracklesham fauna in the Whitecliff Bay section renders the fact very remarkable that great difficulty has been found in attempting to determine the position of the Bracklesham Beds in Alum Bay. This is owing to the absence of fossils in the supposed equivalents of this series in the latter place. It is usually considered that the higher beds of the variegated sands and clays and the beds of lignite belong to this group.

On the mainland the Bracklesham Series occupies a broad zone of country next to the coast, but the beds are in general concealed by superficial accumulations.

About five miles west of Gosport, and a little more than one mile south of the village of Stubbington, is a low cliff consisting chiefly of sands and gravels, but at intervals presenting at its base highly fossiliferous beds belonging to the upper portion of the Bracklesham Series.

This locality has long been known to geologists. It was noticed by Mr. Webster, and in Conybeare and Phillips's "Geology of England and Wales;" and fossils from Stubbington have been described in Sowerby's "Mineral Conchology."

Several of the beds are from time to time exposed in patches on the beach between the tide marks, and I have remarked that this is especially the case after gales from the south-eastwards, during which much shingle is often removed from the shore. South-western gales, on the contrary, appear to heap up shingle over patches previously bare.

The direction of the dip of the beds at Stubbington Cliff is stated by Mr. Fisher to be a little west of south; the lowest beds exposed in this section therefore appear at the north west end of the cliff.

The most westerly spot which I have examined is at the mouth of the Titchfield stream, about one mile west of the end of the lane leading from Stubbington to the shore. Near the mouth of this stream is Hill Head, where, according to Mr. Fisher, in an old cliff there is a bed of large septaria in sand, resting on laminated clay. Here was found a concreted mass of shells, including *Cerithium giganteum*.

The only fossiliferous deposit that I have observed at this spot is a bed of yellow sand, containing casts of univalves, which are in general too imperfect to admit of determination. This bed appears a little above high-water mark at the mouth of the Titchfield stream.

Between Hill Head and the end of Stubbington Lane a flat tract intervenes between the shore and the low cliff. This flat tract is mostly composed of shingle, which nearly opposite Stubbington Lane extends as a spit some distance beyond the general line of the coast. Many recent shells are thrown up on this spit of shingle, and together with them are waterworn specimens of characteristic fossils of the Bracklesham Series, the most abundant of which are *Turritella imbricataria*, *Cardita planicosta* and *Pectunculus*. It is probable that, as suggested by Mr. Fisher, a fossiliferous bed is present at the end of this spit below low-water level.

From Stubbington Lane End a cliff in places about 20 feet high extends for the distance of one mile and a quarter in a south-easterly direction, and it is below this cliff that the best exposure of the strata is seen.* The lowest bed to the east of Stubbington Lane, which is clearly exposed, is a dark coloured sand, 1ft. 8in. thick, which is succeeded by dark green sand (4 feet 7 inches), containing in the lower portion *Pecten corneus*, and in the upper portion many specimens of a variety of *Cardium semigranulatum*, which has been named *C. Edwardsii*. Both these shells are also common in the higher beds of this section. To these beds succeed 6ft. 9in. of dark sandy clay, in the lower part of which *Cytherea lucida* and a *Dentalium* are common. Above this clay is a bed of dark sand, 3 feet 8 inches thick, the denudation of which produces a very striking feature on the beach, as it contains many concretionary masses of sandy limestone or septaria, which are scattered over that portion of the beach where the bed crops out between the tide marks. These concretions are often three feet or more in diameter, are rounded in shape, and are extremely hard. Some of them contain a few fossils, chiefly univalves. The next 17 feet are not very clearly seen. According to Mr. Fisher, the beds consist probably of sands with a few shells. The succeeding bed is a sandy clay, 6 feet 7 inches thick, in which are large flattened calcareous concretions abounding with fossils, and containing masses of wood bored by the *Teredo*. In these concretions *Pinna margaritacea* is common, together with *Corbula pisum* and *Turritella sulcifera*. *Corbula pisum* is also abundant in the next foot of clay, which is greyer and less sandy than the bed below.

Small concreted masses, composed chiefly of the casts of this little *Corbula*, are frequently seen on the beach, and have probably been derived from this bed. The Corbula bed is succeeded by a very dark clayey sand, six feet four inches thick. This bed is often exposed on the beach, and it is at all times seen at the base of the

* Fisher—"Quart. Jour. Geo. Soc.," vol. 18.

cliff, where it can be examined, except at extreme high water of spring tides.

This is the most interesting bed in the section to the palæontologist, as it abounds with fossils. The shells are very fragile, but can be removed with a little care. At the bottom of the bed there is a layer of the large *Cardita planicosta*, which is also met with in the upper part of the deposit.

Among the most abundant fossils may be mentioned *Fusus bulbiformis*, *F. longævus*, *Strepsidura turgida*, *Voluta luctatrix*, *V. Selsiensis*, *Cassidaria coronata*, *C. carinata*, *Conus deperditus*, several species of *Pleurotoma* including *P. attenuata*, *Rostellaria rimosa*, *Trochus agglutinans*, several species of *Natica* or *Ampullaria*, *Turritella sulcifera*, *Crassatella plicata*, *Cytherea obliqua*, *Cardium Edwardsii*, *Pecten corneus*, *Corbula pisum*, *Ostrea flabellula*, &c. *Sanguinolaria Hollowaysii*, *Cypræa*, and many other shells are occasionally found. Teeth of sharks and of rays are not uncommon.

The fine shells of the *Nautilus*, which are so abundant in the Lower Eocene beds of Portsmouth and in the London Clay, are rare in the Bracklesham Series. I have observed two or three specimens in the Stubbington section, but in a very fragile condition.

Many of the above named species are also found in the Barton Clay, and a few are met with in the Lower Eocene. *Voluta Selsiensis*, *Pleurotoma attenuata*, *Sanguinolaria Hollowaysii*, and, perhaps, *Cardita planicosta* are restricted to, and characteristic of the Bracklesham Series.

Above this interesting deposit is a dark greenish-blue clay, four feet six inches thick, abounding with *Corbula pisum*, which is succeeded by three feet three inches of stiff liver-coloured clay, and then follows a bed, four feet six inches thick, of greenish sand. At the bottom of this sand there is a layer of very large specimens of *Cardita planicosta*, many of which are double and in a vertical position. This layer may occasionally be traced across the beach nearly to low water mark. The central portion of this bed is full of *Nummulina variolaria*: this species is readily distinguished by its small size from *Nummulina lævigata*, which prevails in the lower beds of the Bracklesham Series. I have not met with the latter species at Stubbington. The upper part of the Nummulite bed consists of a layer a few inches thick, abounding with the valves of

Pecten corneus. These are difficult to obtain in a perfect condition, as they are extremely fragile.

About thirty-two feet of greenish-blue sandy clay, without fossils, separates the bed last noticed from a layer six inches thick of light greenish sandy clay, which contains a coral and crushed *Dentalia;* and this is succeeded by a bed of light greenish-blue laminated sandy clay fourteen feet six inches thick, which is the highest of the Eocene beds exposed in this interesting locality.

In addition to the two fine natural sections of the Bracklesham Beds seen at Whitecliff Bay and at Stubbington Cliff, deposits belonging to this series have occasionally been exposed in inland localities in the neighbourhood of Portsmouth.

A boring* for a well, executed a few years since at the Waterworks at Bury Cross, one mile west of Gosport, was carried to a depth of 329 feet 9 inches, and passed through beds belonging to the Bracklesham Series, and consisting of alternations of sands and clays, the latter of which prevailed in the lower part. Water was obtained from several of the strata, and pebbles are mentioned as being present in two or three of the beds. The principal fossiliferous bed occurs about sixty-five feet from the surface, and among the fossils are *Nummulina lævigata, Turbinolia elliptica, Pecten corneus, Sanguinolaria Hollowaysii, Turritella imbricataria,* &c. The presence in this section of the *Nummulina lævigata* is evidence in favour of the conclusion that the beds at Bury Cross are lower in the series than those seen at Stubbington Cliff.

Another locality where this series has been exposed is Fort Rowner,† about one mile and a half north-west of Bury Cross, where a bed of sand containing comminuted shells, together with *Turritella imbricataria,* was met with in a well. This bed probably belonged to one of the lower members of the Bracklesham Series.

At Fort Gomer,† to the south of Bury Cross a bed of blue sandy clay was seen, containing *Nummulina variolaria* and *Pecten corneus:* this is clearly the eastward extension of the Nummulite bed of Stubbington Cliff.

I have been informed by my friend Mr. Christian Meyer that *Nummulina variolaria* has been observed by him in a bed of clay occasionally exposed at low water along the shore at Haslar Hos-

* "Quart Journ. Geo. Soc.," vol. 16.
† Fisher—"Quart. Journ. Geo. Soc.," vol. 18.

pital, between the entrance to Portsmouth Harbour and Gilkicker Point.

It is well known that the entrance to the channel leading to Portsmouth Harbour is defended by marine forts built on the adjacent shoals. I have also been informed that at the fort to the east of Southsea Castle, built on the Horse Shoal, *Nummulina variolaria* has been obtained from a well boring in great numbers, at a depth of about 300 feet below low-water mark, and it has lately been met with at a considerably greater depth.

The position of the Nummulite bed in these various localities shows that the strike of the Bracklesham Beds in the Portsmouth district must be from a little north of west to a little south of east.

In the year 1866 extensive excavations were made for the Portsmouth main drainage. The line of sewers extended from Portsmouth across Southsea Common to near Eastney Fort, about three miles to the eastward. The excavations were of no great depth, and, in general, did not extend below the superficial gravel; but on Southsea Common, between the Pier Hotel and Purbeck Terrace, a yellow sand was exposed, which contained in great abundance *Cardita planicosta* and *Turritella imbricataria*. The fossils were extremely delicate; but in addition to these, I was able to identify *Cardita tenuicosta, Ostrea flabellula, Cytherea, Corbula, Cardium Edwardsii, Turritella sulcifera, Fusus longævus, Voluta,* and *Natica.*

I did not obtain any Nummulites from this locality, but it appears probable that this bed belongs to the lower part of the Bracklesham Series, since it is about one mile to the north-east of Haslar, where the bed with *Nummulina variolaria* is at the sea level. *Cardita acuticosta* is a shell that I have not observed at Stubbington, but it is common in the lower beds of the series at Bracklesham. *Turritella imbricataria* is not abundant at Stubbington, except in the Hill Head bed; it abounds in some of the lower layers in Whitecliff Bay, and also at Bracklesham. At both these localities, and also at Southsea, this shell is associated with *Cardita planicosta.*

From these various sections it appears probable that the Bracklesham Series occupies the tract of country nearest to the coast in the neighbourhood of Portsmouth. It possibly forms a zone, surrounding the Chalk elevation of Portsdown, since, at Emsworth Common, about three miles to the east of that hill, a Nummulite was met with many years since and was described by Sowerby, and in a line due west of this same hill, Mr. Fisher noticed, at Netley Hospital near Southampton, a bed of clay with *Pecten corneus*.

The highest members of the series occupy a considerable extent of the surface of the New Forest, especially in the neighbourhood of Lyndhurst and Brockenhurst, where they abound with well-preserved fossils, and Mr. Fisher assigns to the Bracklesham Series about 50 feet of fossiliferous sands more or less argillaceous, (including two bands of flint pebbles), which form part of High Cliff to the east of Christchurch.

There does not appear to be any clear evidence of the extension of this series into Dorsetshire. Mr. Fisher only records that a concretion of ferruginous sand with *Cardita planicosta* and *Turritella* was said to have come from Lytchet, near Wareham.

In the London Tertiary area the Bracklesham Series is considered by Mr. Prestwich to be represented by the middle portion of the Bagshot Sands. These beds are seen at several localities in the neighbourhood of Bagshot Heath,* where they consist of green-sands and sandy clays, and occasionally beds of pebbles. The mineral character of these deposits corresponds closely with that of the Bracklesham Beds of Hampshire, but the rich fauna so characteristic of the series in the Hampshire area is here wanting. The middle division is recognised by being more argillaceous in character than the Upper and Lower Bagshot Beds, and is from 30 to 60 feet thick. Organic remains are scarce, but in a few localities casts and impressions of shells of species very characteristic of the Bracklesham period have been obtained. Mr. Prestwich mentions among others *Nummulina lævigata*, *Ostrea flabellula*, *Turritella sulcifera*, *Cardita acuticosta*, and *C. planicosta*. In a cutting on the line of the London and South-Western Railway at Goldsworth Hill, near Woking, the remains of several species of fishes belonging to the chimæroid, shark, and ray families have been found.

The Bracklesham Series is represented in the Paris Tertiary area by the Calcaire Grossier,† a deposit which is extremely rich in organic remains, although its maximum thickness does not exceed 150 feet. The Calcaire Grossier consists (in the lower portion) of calcareous greensands, sometimes concreted, having often flint pebbles at the base, succeeded by soft light yellow calcareous free-

* Prestwich—"Quart. Journ. Geo. Soc.," vols. iii. & xiii.
† Prestwich—"Quart. Journ. Geo. Soc.," vol. 13.

stone, and then by calcareous flags and sandstones alternating with white marls and limestones, and the upper part is composed of compact white marls passing down into beds, alternating with greenish marls and thin yellow limestones with seams of chert.

The freestone contains many marine organic remains, but the highest beds contain fossils of estuarine and fresh-water types, with which marine forms, corresponding with those of the Bracklesham Series, are occasionally associated.

Nummulina lævigata is present in the Calcaire Grossier, but *N. variolaria*, which characterises the upper portion of the English series, is in France met with in the Sables Moyens, the next group above. In the neighbourhood of Brussels the Bracklesham group is represented by about 100 feet of sands and calcareous greensands with occasional concretions, and contains many fossils, including *Nummulina lævigata.*

UPPER BAGSHOT SERIES, BARTON CLAY AND HEADON HILL SANDS. —Between Lymington and Christchurch the cliffs on the coast of Hampshire present a fine section of strata, consisting of yellow and white siliceous sands and sandy clay, and thick beds of clay with septaria, below which are sandy clays and greensands, based on a bed of flint pebbles about one foot thick. The total thickness of this series is about 330 feet. The central argillaceous portion has long been celebrated for the variety and the excellent state of preservation of its marine fossils. It is known as the Barton Clay.

The argillaceous character of these Barton deposits, and the supposed correspondence of the fossils with those obtained from Highgate Archway, caused the earlier geologists to consider that the Barton Clay was of the same age as the London Clay of the London area, but Mr. Prestwich has shown that a very small percentage of the fossils of each of these deposits is common to both, and that the Barton Clay and the Bracklesham Beds are both more recent than the London Clay.

In Alum Bay a pebble bed above the variegated sands and clays and the lignites is succeeded by argillaceous beds nearly 300 feet* in thickness, which contain many marine fossils corresponding with those from Barton, above which are about 100 or 140 feet of white siliceous sands, which Mr. Prestwich has grouped with the bed below, because, although destitute of fossils in Alum Bay, the

* Prestwich—"Quart. Journ. Geo. Soc.," vol. 13.

supposed equivalent in Whitecliff Bay contains marine fossils apparently of Barton forms. These sands are usually known as the Headon Hill Sands, as they are there worked for the purpose of glass making.

In Whitecliff Bay a bed of flint pebbles is selected by Mr. Prestwich as the base of the Barton Series. Here, as in the other localities, Mr. Fisher claims for the Bracklesham Series strata above this pebble bed.*

The siliceous sands are thicker in the Whitecliff section than at Alum Bay; according to Mr. Prestwich they are 202 feet thick. The lower portion of the group has a thickness of 288 feet. This argillaceous portion includes more intercallated sandy beds than are met with at the west end of the island.

The siliceous sands contain† ferruginous friable casts of *Cardium*, *Tellina*, *Panopæa*, &c., and the lower beds *Tellina*, *Actæon*, *Nummulina variolaria*, *Corbula pisum*, *Pectunculus deletus*, &c.

The Barton Beds are not exposed on the main land in the neighbourhood of Portsmouth. If they are present in the district it would be at the most southerly extension of the land at Gilkicker Point, between Stokes Bay and the entrance to Portsmouth Harbour. The well boring at the Horse Fort showed the bed with *Nummulina variolaria* at a depth of nearly 300 feet below low water mark. I have not obtained any particulars of the deposits passed through between that bed and the surface of the shoal, but possibly some of the upper strata may represent a portion of the Barton Series.

In the London area the representatives of the Bracklesham Beds are succeeded by the Upper Bagshot Sands (the highest of the Eocene beds of the London district), which consist ‡ of irregularly bedded yellow, green, red, or ochreous sands, with ironstone concretions, blocks of light saccharine sandstone and flint pebbles. These sands are from 250 to 300 feet in thickness. Fossils are rare in these beds, but casts of shells, including those of a small *Cardium*, are occasionally met with. The Upper Bagshot Sands are perhaps equivalent to the Barton group.

On the Continent the Barton Beds are, according to Mr. Prestwich, represented in the Parisian area by the Sables Moyens, a

* See Fisher—"Quart. Journ. Geo. Soc.," vol. xviii.; and Prestwich—"Quart. Journ. Geo. Soc.," vol. xiii., p. 109, note.
† Bristow—"Mem. Geo. Survey."
‡ Prestwich—"Quarterly Journal Geo. Soc.," vols. iii. and xiii.

group from 80 to 120 feet in thickness, consisting of alternations of marls and quartzose and calcareous sands, based on a conglomerate of flint pebbles. The Sables Moyens contain marine organic remains, many of which are Barton forms; they also contain *Nummulina variolaria* and other fossils met with in the Bracklesham Beds of England. In the pebble bed at the base, fossils from the Lower Eocene and from the Calcaire Grossier are met with, including *Cerithium giganteum* and *Nummulina lævigata.*

In Belgium about 30 feet of green and yellow sands, known as the Laeken Beds, are assigned to this horizon. They contain Barton and Bracklesham forms in nearly equal proportions.*

Mr. Prestwich has distinguished the Bagshot, Barton, and Bracklesham Beds and their equivalents as the "Paris Tertiary Group," as the organic remains of this period are far more abundant in the French area than in that of England, and he considers that the general character of this group denotes that at the commencement of the Lower Bagshot Series there was † "a subsidence of a southern land and an extension of the sea over the previously littoral and dry portions of the Paris district." "A further but minor change afterwards took place, marking the commencement of the Bracklesham Sands and Calcaire Grossier period; the former sea bed seems to have been enlarged and further extended, and a fauna of a still more southern facies introduced;" but "the Barton Clay sea seems again to have been more connected with water opening to the northward than did that of the Bracklesham Sands," as the fauna of the Barton Clay "has not so southern an aspect as that of the Calcaire Grossier and Bracklesham period."

Upper Eocene.—The strata of the Lower and Middle Eocene periods appear to have been deposited in an area of slow but continued depression. The beds succeeding the Barton Series and its equivalents show, both in England and in France, a marked change in the conditions under which they were deposited. The prevailing fossils of most of the higher strata are of a fresh-water or brackish-water character, marine shells being present only in a few of the beds. These fluvio-marine strata must have been deposited in areas closely connected with extensive tracts of dry land, and they indicate that after or towards the close of the

* "Quarterly Journal Geo. Soc.," vol. xiii, pp. 127, 131.
† "Quarterly Journal Geo. Soc.," vol. xiii.

deposition of the Barton Series the action of depression for a time ceased, and perhaps gave place to one of elevation, and these causes resulted in a considerable change in the physical geography of the period.

It seems most natural to draw the line of division between the Middle and the Upper Eocene deposits at the point where this great physical change is first indicated.

In England the Upper Eocene, or fluvio-marine deposits, occupy the surface of a great portion of the Isle of Wight, to the north of the central Chalk range, and beds of this age also cover a limited area in Hampshire between Barton and Lymington. They were first described in the year 1816 by Mr. Webster, and they were subsequently studied with great care by the late Professor Edward Forbes, who in the year 1853 communicated to the Geological Society the result of his examination of these strata.* Professor Forbes showed that this formation was thicker than had previously been supposed, and that it was divisible into four distinct groups, to which he assigned the names of the Headon Series, the Osborne or St. Helen's Series, the Bembridge Series, and the Hempstead Series. Three of these groups are exposed in Whitecliff Bay.

HEADON SERIES.—These beds are best exposed at Headon Hill, at the west end of the Isle of Wight; they also appear above the sea level at East Cowes, in consequence of the fault which occurs in the valley of the Medina, and they are seen in a highly inclined position in the cliffs in Whitecliff Bay.

At Headon Hill the lower portion of the group, which is about 67 feet thick, consists of bands of light-coloured limestone, sandy in some of the layers, alternating with beds of sand and of clay. These beds are of fresh-water or estuarine origin, the prevailing fossils being *Planorbis euomphalus*, *Limnæa longiscata*, *L. caudata*, &c.

The middle portion of the series is about 30 feet thick and is of brackish water origin, consisting of clays and ferruginous sands, containing *Potamides ventricosus*, *P. concavus*, *Neritina concava*, *Fusus labiatus*, *Cyrena obovata*, *Cytherea incrassata*, *Psammobia solida*, &c.

The upper beds show a recurrence of fresh-water conditions, as

* See also Mem. Geological Survey.

they are composed, throughout a thickness of 80 feet, of clays marls, and thick-bedded limestones, containing *Limnæa*, *Planorbis* *Paludina*, *Bulimus*, &c.

Throughout the Headon series, *gyrogonites*, or the small spherical seed vessels of *Chara* are abundant. From these beds the remains of a fresh-water turtle and teeth of *Palæotherium*, have been obtained.

Traced to the northward into Colwell Bay, the Middle Headon Beds become more marine in character, and the upper fresh-water beds are thinner. The lower and middle portions of the Headon Series are well seen on the opposite coast of Hampshire at Hordwell Cliff, between Barton and Lymington. The limestones are not present in this section, the beds consisting of sands, clays, and marls, about 90 feet thick, with fresh-water or brackish-water fossils. Numerous remains of Mammalia and Reptilia have been obtained from this spot.

On the shore at East Cowes the Headon Beds appear as brackish-water sands and clays.

In Whitecliff Bay the Headon Beds are seen in the cliff. The beds of limestone are absent, and the lower portion is at this spot about 30 feet in thickness, and consists chiefly of beds of purplish and greenish clay, containing *Planorbis euomphalus*, *Limnæa*, and other fresh-water shells, and there is a bed of lignite one foot thick near the top. The Middle Headon division is here about 100 feet thick, is represented by thick beds of sand with thinner bands of clay, and contains *Cytherea incrassata*, *Fusus labiatus*, *Bulla*, *Calyptræa*, and other marine shells. In the upper portion the brackish and fresh-water conditions are again indicated by beds of clay and occasionally of sand, with *Unio*, *Cyrena*, *Paludina*, *Limnæa*, and *Planorbis*, together with the seed vessels of *Chara*. These beds are about 40 feet thick.

Osborne or St. Helen's Series.—This group was first noticed by Professor Forbes, and was so named by him from the fact that deposits of this age appear on the north coast of the island between St. Helen's and Ryde, and also form the surface of part of the royal grounds of Osborne. These beds are also present in the upper part of Headon Hill, in Tollands and Colwell Bays, and at Whitecliff Bay.

At Headon Hill the series consists of marls with hard bands and nodules of argillaceous limestone, containing *Limnæa*, *Planorbis*, and *Paludina*. These beds are 40 feet thick, and increase in thickness to 60 feet in Colwell Bay.

In Whitecliff Bay the Osborne Beds are at first highly inclined, but the upper portion follows the curve of the limestone above, and becomes nearly horizontal; they are here 100 feet thick. The strata are frequently concealed to a great extent by landslips, but they consist chiefly of greenish clays and marls. A thin band of yellow limestone, about 36 feet above the Headon Beds, contains *Helix occlusa*, *Planorbis discus* and *Limnæa longiscata*.*

Between St. Helen's and Ryde the sloping cliffs are covered to a great extent with vegetation. Along this coast the Osborne Beds are raised above the sea level in an arched form, and are seen at intervals on the shore. Professor Forbes has formed two sub-divisions of the series as represented in this locality. The higher of these sub-divisions he has termed the St. Helen's Sands, which consist of beds of green, yellow, and white sands, and concretionary sandstone, with a bed of greenish blue clay at the base, and a band of dark greenish carbonaceous clay at the top. This division is about 48 feet thick, and contains *Melania*, *Hydrobia*, *Helix*, *Limnæa*, *Planorbis*, and *Cyrena*. The lower division, which the Professor named the Nettlestone Grits, consists of soft limestones, marly clays, and sandstones, and a freestone, with siliceous concretions passing into a grit, in which flint pebbles are occasionally found. This division is about 20 feet thick, and it also contains fresh-water fossils.

The red and white clays, which are worked for bricks at Little Apley Wood, to the east of Ryde, are considered to belong to the Osborne Series, as are also the various blocks of grit on the shore between Ryde and Seafield.

The beds between Wootton Creek and Osborne consist of red and green clays with limestones, sandstones, and marls, abounding with fresh-water fossils, and representing the St. Helen's division, to the west of which are calcareous ragstone, sandy limestones, blue, purple, and dark shales, and yellow sands, also containing fresh-water forms which correspond with the Nettlestone Grits.

Bembridge Series.—The deposits assigned by Professor Forbes to this series occupy the surface of a large portion of the Tertiary

* "Forbes' Mem.," p. 73.

district of the Isle of Wight. The typical section of the group is seen in the cliffs, and on the shore between Whitecliff Bay and Bembridge Point. In the southern part of this section the Bembridge Limestone (the lowest member of the series) has a considerable inclination to the north, but it soon curves round and becomes nearly horizontal, occasionally disappearing below the level of the sea, and at other points appearing as the lowest stratum above the beach.

Near Bembridge Point it rises again, and forms a ledge, which extends a considerable distance out to sea.

The Bembridge Limestone in Whitecliff Bay averages about 26 feet in thickness. It there consists of beds of compact or marly limestone, with an interstratified band of grey marly clay in the lower part. The whole abounds with casts of *Limnæa*, *Planorbis*, and *Helix*, together with the seed vessels of *Chara*. From one of the beds of limestone the fan-shaped leaf of a palm has been obtained.*

The limestone is succeeded by beds of marl, clay, and sand, about 130 feet thick, which are known as the Bembridge Marls. The most abundant organic remains in these deposits are *Paludina*, *Melania*, and several species of *Cyrena*. Not far from the base of the series is a greenish sandy band which contains marine fossils, including an oyster and casts of *Cytherea incrassata*. This bed was for a long time confounded with the middle and marine division of the Headon Series, which is in truth present lower in the Whitecliff section. The oyster-bed occupies a portion of the beach in Whitecliff Bay where it can be well examined.

A few feet above the marine band is a bed of clay containing well-preserved examples of *Cyrena*, especially *Cyrena semistriata*, and the large species *Cyrena pulchra*. From a bed near this part of the cliff Professor Forbes obtained the greater part of the carapace of a turtle (*Trionyx*).

About 50 feet above the base of the marls there is a band of sandy limestone, sometimes passing into a marl, about four feet thick. This limestone contains *Cyrena*, *Paludina*, and *Melania*, and occasionally *Unio*, *Limnæa*, *Bulimus*, and *Achatina*, and the seed vessels of *Chara*. This bed, which indicates a repetition, to a certain extent, of the conditions under which the Bembridge Limestone

* Mantell's "Isle of Wight."

was deposited, forms the base of the upper division of the Bembridge Marls. It is succeeded by about 40 feet of clays, shales, and sandy beds, with *Paludina lenta, Melanopsis fusiformis, Melania turritissima*, &c., with remains of fish.

To the north-west of Brading Harbour the Bembridge Series is seen on the shore and in the cliff* below St. Helen's. The beds of limestone with fresh-water fossils appear on the shore, where they have a dip at a slight angle to the south-east. To the north the lowest stratum of the limestone is seen to rest on stiff green clay, belonging to the Osborne Series. One bed or layer of the limestone contains a small oyster associated in the same blocks with *Limnæa.* From this band I obtained two teeth of *Lamna. Helix occlusa* and *Bulimus ellipticus* are found occasionally. The marls above contain *Cyrena obovata, Paludina lenta, Melanopsis fusiformis,* and *Cerithium mutabile.* One thin band abounds with the small *Melania muricata.*

The Bembridge Limestones and Marls are occasionally seen on the north coast of the island between Ryde and Osborne. The series is also well seen between West Cowes and Gurnet Bay, at which places the *Chara* seeds are very abundant in the limestone, and the band with *Melania muricata* is seen in the marls.

Further to the west a very complete section of this series is seen on the shore between Hampstead Ledge and Yarmouth. This section has been measured by Professors Ramsay and Morris, and Mr. Bristow, and the details have been published by the last-named gentleman in his "Memoir on the Isle of Wight."

The Bembridge Limestone appears in the cliff at Sconce Point to the west of Yarmouth; it is there from sixteen to twenty feet thick, and the upper part is remarkable for the abundance of land shells, *Helix, Bulimus, Achatina*, &c., which it contains. In one layer there are some masses regarded by Mr. Edwards as turtles' eggs.

The Bembridge marls and concretionary limestones are feebly represented at the top of Headon Hill, and, according to Professor Forbes, the fossils† "in the concretions are almost invariably terrestrial." This fact, and also the presence of oysters and sharks' teeth in the limestone at St. Helen's, indicate that the sea of this period must have been situated to the eastward.

The Bembridge Limestone is seen in several localities in the

* A portion of this cliff was a few years since faced with stone.
† Forbes's Mem., p. 58.

interior of the island, especially in the neighbourhood of Ryde, and at Calborne to the west of Carisbrook. There is an old quarry of the limestone, and also a section of the marls, not far from the Ryde Railway Station. The quarries at Binstead, one mile west of Ryde, are well known. The strata in these quarries consist* of beds of compact and of shelly limestone, associated with sands and clays. *Bulimus ellipticus* is found at this spot, and occasionally bones of turtle, and the teeth and bones of Mammalia of the genera *Palæotherium*, *Anoplotherium*, *Chæropotamus*, &c.

HEMPSTEAD SERIES.—The Bembridge Marls are the highest deposits of Eocene age seen in the Whitecliff and Bembridge section. At Hampstead Hill, to the east of Yarmouth, Professor Forbes distinguished a group of deposits above the Bembridge Marls, 170 feet in thickness, to which he has assigned the name of the Hempstead Series. This group is composed of fresh-water and estuarine marls or clays, with fifteen feet of clays with *Corbula* and other marine fossils at the top.

The Hempstead Beds are not clearly exposed in any other part of the island, but it is considered that the highest part of the ground by Parkhurst Forest belongs to this series.

At one of the earlier meetings of the Geologists' Association, Dr. Wilkins of Newport, in a short paper, gave an account of some excavations in the neighbourhood of Osborne. Judging from the fossils he obtained from these excavations, he considered that the beds belonged to the Hempstead Series. This is the only instance recorded of the presence of these beds to the east of the Medina.

The foreign equivalents of each of the fluvio-marine series of the Isle of Wight do not appear hitherto to have been clearly determined. By Professor Forbes the Headon Beds were supposed to be represented in the Paris area by the Sables Moyens; but as Mr. Prestwich has shown that this French group approaches in age to the Barton Clay, it is necessary to look higher in the Paris series for the equivalents of the Upper Eocene of the Isle of Wight.

The Sables Moyens, or Grès de Beauchamp, are succeeded by a limestone,† sometimes grey and compact, and penetrated by silex, but often cellular. ‡" It is for the most part devoid of organic remains, but in some places contains fresh-water and land species,

* Mantell's "Isle of Wight."
† De La Beche's "Manual," p. 226.
‡ Lyell's "Manual," 5th edit., p. 226.

and never any marine fossils." Above this siliceous limestone is a group of beds, which have long been celebrated, having afforded to Cuvier the remains of extinct Mammalia, &c. This series consists* of an alternation of gypsum and calcareous and argillaceous marls, above which are thick beds of similar marls. These marls contain *Limnæa* and *Planorbis*, and the remains of palms and of other land plants. Above these beds is a series of siliceous sandstones and sands with marine organic remains, known as the Grès de Fontainebleau, succeeded by a fresh-water limestone and marls, called the Calcaire de là Beauce. The whole of these deposits show that in the Paris area conditions prevailed after the deposition of the Sables Moyens very similar to those of the Hampshire area after the close of the Middle Eocene period.

In Belgium the fluvio-marine beds of the Isle of Wight, or a part of them, are considered by Sir Charles Lyell to be represented by the Limberg Beds. These are composed in the lower part of greensands with marine fossils, succeeded by fluvio-marine sands and marls, above which are clays and loams with *Leda* and other marine species.

The details of the Isle of Wight beds indicate that the seas of the period were probably situated to the east, and this is confirmed by the marine and estuarine character of the Belgian deposits.

Although the numerous species of *Limnæa*, *Planorbis*, *Paludina*, and *Unio*, met with in the Upper Eocene of Hampshire, are very similar to species now living in the ponds and rivers of England, the general character of the organic remains of these groups indicates a warmer climate than that which now prevails in this country.

It was suggested that at the commencement of the Upper Eocene period a movement of elevation took place. If the freshwater limestones were formed in a similar manner to the lacustrine shell marls of the present day, they may mark intervals during which the land was stationary, followed by periods of depression indicated by the marine and brackish-water sands and marls; such conditions appear to have been at least twice repeated, the Headon and Osborne Groups representing the first of these periods of rest and depression, and the Bembridge and Hempstead Series a second period of similar action.

* De La Beche's "Manual."

If there have never been above the Hempstead Beds other marine or fresh-water deposits which have been subsequently entirely removed by denudation, it is probable that at the close of this period a considerable elevation of the area took place, and that during the Miocene and possibly the Pliocene epochs the British area, or a great part of it, was in the condition of dry land.

Gravels and Superficial Deposits.—The gravels and the other superficial deposits of the Hampshire Tertiary area have been studied by Mr. Godwin-Austen, Mr. Bristow, and Mr. Codrington.

In the Isle of Wight gravel composed of broken flints, mixed with patches and layers of sand, covers the tops of hills at heights of from 100 to 300 feet above the sea, and is considered by Mr. Codrington to coincide with a plain, having an uniform slope towards the north. No organic remains have been found in this gravel.

At a lower level a thick deposit of gravel is seen at the foreland to the north of Whitecliff Bay. This gravel increases from a few feet to between 30 and 40 feet in thickness, and consists* of well-rounded flints, with occasional blocks of greywether sandstone and fragments of chert and sandstone derived from strata below the Chalk; the whole is interstratified with layers and seams of sand.

A similar gravel is seen at St. Helen's, but it is not there so thick as it is at the foreland.

A gravel containing rounded flints of considerable size is seen at King's Quay by the road from Osborne to Wootton, and there is a similar gravel on the shore to the east of Ryde.

A bed of brick earth, from 6 to 36 feet in thickness, caps the gravel of Whitecliff Bay, and extends beyond it nearly to the Chalk range. This bed is in places eroded, and above it is a drab coloured loam. In other parts two beds of peat and a bed of brick earth are associated with the upper portion of the gravel. The peat contains hazel nuts and the remains of large trees and of beetles. Mr. Codrington has obtained a flint implement from this brick earth. The foreland gravel is considered to be the western extension of the raised beach at Brighton, which has been described by Dr. Mantell.

At Wootton Creek, about three miles west of Ryde, a brick

* Bristow—" Mem. Geo. Survey."

earth, composed of deep brown sandy clay containing small angular fragments of flint, occurs in patches. It varies in thickness from six to thirty feet, and extends about thirty feet up the slope of the hill.*

The gravels on the main land of Hampshire also occupy two distinct levels. Mr. Codrington† states that "the table land of Titchfield Common is separated from the lower ground of Chilling and Brunage by a tolerably well defined step. Titchfield Common and the table land about it is gravel covered; but this appears not to be the case with the corresponding level between Titchfield and Fareham." The gravels seen in the cliffs at Hill Head and Stubbington, and at Alverstoke, belong to a lower level. Stubbington Cliff is being constantly wasted by the action of the waves and of the atmosphere. About ten years since it presented the following general section, in descending order:—1st, brown clay, from two to three feet; 2nd, clay and broken flints or shingles, one to three feet; 3rd, brown and grey variegated clay with a few flints, one foot; 4th, yellow and variegated sands with broken flints, about two feet six inches; 5th, yellow and light-coloured sand with bands of shingle, two feet to three feet six inches; 6th, shingles, flints, and sands, from seven feet to eleven feet; 7th, fossiliferous Eocene sandy clay. The junction between 5 and 6 was irregular.

Many flint implements have been obtained from the cliffs between Southampton Water and Gosport.‡ They have in general been picked up on the beach. No organic remains have been found in the gravels covering the plains.

The district to the east of Portsdown Hill also shows two distinct deposits of gravel at different levels. A section given by Mr. Codrington shows gravel on Bourne Common at a height of 142 feet above the sea, and the low lying tract to the south of Bourne, including Hayling Island, is also covered with gravel.

The superficial deposits of the district to the south and south-east of Chichester have been studied and described by Mr. Godwin-Austen.§ That gentleman states that there is in that district an upper zone of flint gravel at a slightly higher level than a lower

* Bristow—"Mem. Geo. Survey."
† "Quart. Journ. Geo. Soc.," vol. 26.
‡ Codrington, "Quart. Journ. Geo. Soc.," vol. xxvi.
§ "Quart. Journ. Geo. Soc.," vol. 13.

series. The upper series is coloured by oxide of iron, and is locally known as "red gravel." That of the lower level is distinguished as "white gravel." The red gravel appears to have originally extended over the whole of the district, and patches of it are seen below the low level gravel in Bracklesham Bay, at Selsea Bill, and in Pagham Harbour, extending as far as the line of low-water. At these localities there are some remarkable deposits below the more recent gravel, and apparently above the red gravel. The lowest of these beds consists of an extremely fine sandy mud, which in some instances attains a thickness of from eighteen to twenty feet. This deposit contains many marine shells, belonging, with a few exceptions, to species now met with in the British seas, and especially in the sea to the south and west, but two of the characteristic shells, *Pecten polymorphus* and *Lutraria rugosa*, do not at present range further north than Lisbon.* The remains of *Elephas primigenius* have been obtained from this bed.

The mud deposit is succeeded by a yellow calcareous or sandy clay, with many small fragments of chalk, and water-worn Chalk flints, together with *Littorina* and *Mytilus*. This bed is remarkable for containing shingle and sub-angular blocks of granites, syenites, hornblendic greenstone, mica-schist, green slates, and other crystalline and palæozoic rocks, many of the blocks being of large size.

Above this boulder clay is a bed of coarse flint gravel, passing occasionally into horizontal bands of sand and shingle with marine shells. This gravel contains pebbles of old and crystalline rocks much water-worn and never of large size.

The highest deposit on this coast is an unstratified clay or brick earth, with an average thickness of from two to three feet. In inland districts this brick earth contains *Helix* and *Succinea*.

The gravel of Portsea Island does not present, as the gravels to the east and west do, evidence of having been deposited at two distinct levels, but it forms a sheet which extends to the base of Portsdown Hill.† At Southsea it is in places at least 27 feet thick, and is covered by brick earth. Mr. Codrington states that numerous

* A large number of species have been obtained by Mr. A. Bell.
† Codrington—"Quart. Journ. Geo. Soc.," vol. xxvi.

blocks of granite, syenite, greenstone, and sarsen stone are found in this gravel.*

At the time when the sewers were being constructed across Southsea Common, a local mud deposit was exposed nearly opposite the Pier Hotel, beneath three feet of angular gravel. This mud contained in great abundance *Cardium edule*, *Scrobicularia*, and a few other marine shells, and it closely resembled the recent mud of Portsmouth Harbour. Although this mud is below a bed of gravel, it is probably a very recent deposit, as about thirty years since a small pond or inlet of the sea existed at this spot, which has since that time been filled up with gravel from the neighbourhood.

Between Stubbington Cliff and Anglesey, near Gosport, a low tract known as Browndown (which is used by the Government for rifle practice) intervenes between the continuation of the cliff and the shore. It is slightly above high-water mark, and is composed of shingle resembling that which extends over parts of Southsea Common. It contains numerous oyster and other shells.

Mr. Codrington is of opinion "that a gradual upheaval appears to have gone on from the time of the oldest and highest gravels down to the date of the low level gravels."

Other recent deposits appear to indicate a depression of the area under consideration. These are old land surfaces and sunk forests, seen below the level of low water. One of these land surfaces is mentioned by Mr. Godwin-Austen, as "exposed at extreme low water to the east of Southsea Castle passing beneath the sea." Mr. Fisher alludes in his paper to a sunk forest at the east end of Stubbington Cliff.

Sir Henry James has described a section seen in one of the docks at Portsmouth, where at about eight feet below low-water mark a layer with stems of trees and stumps rooted in the Eocene clay was seen beneath a band of shingle and estuary mud containing marine shells.

* In a communication to the Geological Society, read 6th December, 1871, Mr. Prestwich described a section of gravel observed by him in a pit at East Cams Wood, near the western termination of Portsdown. This section is at the height of 125 feet above the sea level, and "shows laminated sands with seams of shingle, overlying coarse flint shingle with a few whole flints, which the author regarded as a westward continuation of the old sea-beach, which has been traced from Brighton, past Chichester, to Bourne Common." (Abstracts of "Proc. Geo. Soc.," No. 240.) The position in which this gravel is found is very interesting. It has hitherto only been observed at that part of the hill where the southern slope of the Portsdown anticlinal has been preserved, and it appears to rest on this slope. Should this prove to be the case it would show that a vast amount of denudation has probably taken place subsequent to the deposition of this gravel.

A terrestrial surface with roots of vegetation in position is seen in a similar position beneath the mud of the harbour in the extensive excavations now being made for the new docks. This recent mud in some spots attains to the thickness of 35 feet, and covers a considerable portion of the harbour. "It* contains in abundance the common cockle (*Cardium edule*), the periwinkle (*Littorina littorea*), *Tellina*, *Scrobicularia*, and *Littorinella ulvæ*, species now living in the surrounding area." There are also extensive mud flats in the adjacent harbours of Langston and Emsworth.

Further evidence of depression is recorded by Mr. Godwin-Austen† in the Isle of Wight.

An old well, lined with stone and filled with estuary mud, was discovered during an attempt to reclaim Brading Harbour, "at a spot which previously had been and now is permanently submerged."

Along the shore near Ryde there is an extensive tract left dry at low-water, which is covered with a sand sufficiently firm to bear carts laden with coals and other merchandise on its surface. Mr. Godwin-Austen states that "when Fielding was at Ryde, on his voyage to Lisbon in 1753, he describes it as totally inaccessible by sea, except at or near high-water, as the tide left a vast extent of mud, too soft to bear the slightest weight." Mr. Austen has ascertained that this mud deposit now exists below many feet of sand, yet "the sands are bare at low-water, but not to a greater extent than were the former mud banks." A considerable depression has, therefore, probably taken place in the neighbourhood of Ryde within the last century, and it is perhaps still going on.

Should the evidence of this recent depression be confirmed, it would afford an explanation of the manner in which many of the Lower and Middle Eocene strata have been formed. It has been suggested in the earlier part of this paper that a slow depression of this area resulted in the deposition, during a long period, of alternations of clays and sands at a very moderate depth below the level of the sea. In the Ryde mud and sand bank we have evidence that a similar cause is producing a similar alternation of deposits at the present day.

* Morris—"Hampshire Telegraph," Sept. 24, 1870.
† "Quart. Journ. Geo. Soc.," vol. 13.

ORDINARY MEETING, March 3rd, 1871.

The Rev. Thomas Wiltshire, M.A., F.G.S., &c., President, in the Chair.

The following donations were announced:—

"Journal of the London Institution," from that Institution.

"Journal of the Statistical Society," from that Society.

"Abstract of Proceedings of the Geological Society," from that Society.

"The Quarterly Journal of the Geological Society," from that Society.

"On the Claims of Science to Public Recognition and Support."

The following were elected Members of the Association:—

J. E. Stuart Forbes, Esq., Adam Murray, Esq., F.G.S., and John William Elwes, Esq.

The following Paper was read:—

"On the Range of Foraminifera in Time."

By Professor T. Rupert Jones, F.G.S., Hon. Mem. Geol. Assoc. &c.

(With a Table.)

The Rhizopods with calcareous shells, namely, all the Foraminifera except the family *Gromida*, it is well known, have three principal kinds of shell-structure, that is to say (1) the opaque or "porcellanous," without tubules and pores (*Imperforata*); (2), the subtranslucent, or "hyaline," with tubules and pores (*Perforata*); and (3), the opaque and sandy, or the "arenaceous" kind. The last mentioned appears to be, in some instances at least, a modification of the porcellanous kind, by the addition of grains of sand, comminuted shells, minute Foraminifera, &c., in variable proportion to the calcareous matrix, and with differences of arrangement, the particles sometimes projecting beyond the surface, and sometimes neatly imbedded, as sand in smooth cement. So also some of the "hyaline" forms (as *Textilaria* and *Bulimina*) become rough and thickened in the aged state, with the imbedding of foreign particles. The "arenaceous" shells, therefore, do not constitute a really distinct zoological group, though convenient as comprising the common *Lituolæ*, *Valvulinæ*, *Trochamminæ*, &c.

1. The "porcellanous" Foraminifera have, with a similar kind of shell-structure, widely different forms, which may be arranged (as

in Carpenter's "Introduction to the Study of Foraminifera," 1862 p. 67), in a series which commences with a simple tent-like scale, progresses by sub-discoidal augmentation of segments, though modified either by linear or cyclical growth, until, from the monothalamous *Squamulina*, we pass through *Nubecularia*, *Vertebralina*, *Peneroplis*, and *Orbiculina*, to *Alveolina*, *Orbitolites*, *Dactylopora*, and *Acicularia*. Again, recommencing with the simplest form, we have it tubular and coiled discoidally in *Cornuspira*, folded in hanks in *Miliola;* and this is modified by internal thickenings and labyrinths in *Hauerina* and *Fabularia*.

2. Opaque shell-matter, with more or less embedded sand, characterizes the *Lituolida*. These comprise *Trochammina*, which has a *smooth* surface; and *Lituola* with a *rough* surface. The former may be as simple as *Squamulina*, also flatly discoid, like *Cornuspira*, and is sometimes Milioloid; but it diverges from that set of forms in taking on Nautiloid, or rather Rotaline shapes, whilst, as globular and fusiform shapes, *Parkeria* and *Loftusia* are gigantic and complex members of this group.

Lituola has its segments arranged sometimes like some *Nubeculariæ*, irregularly moniliform, and attached to some surface; frequently straight and symmetrical as a *Nodosaria*, or crozier-wise, like the narrow *Peneroplides;* and not rarely in Nautiloid or thick discoidal shapes. Like *Trochammina*, therefore, it has a mode of growth not attempted by the Miliolids. *Saccammina* is a globular or ovoid form. The inside of the chambers in *Lituola* are often labyrinthic; the more simple forms are separated under the name *Haplophragmium*, by Reuss. *Lituola* and *Trochammina squamata* pass one into the other by intermediate forms. The same species of *Trochammina* has its transitions into the least conical forms of *Valvulina* (Brady); and *Troch. inflata* passes into Nonionine *Lituolæ*.

On the other hand, *Troch. incerta* is a very near relation of *Involutina* and *Endothyra*, of which *Fusulina* is a clear-shelled and fusiform ally. Again, there is little doubt that some of the sandy Textilarians of the Mountain-limestone are closely connected with this Lituoline group, and lead us towards *Bulimina*.

2*. *Valvulina*, sandy in the full-grown state, is for convenience included with the "Arenaceous" forms, although its young shell is "hyaline" or vitreous, and not "porcellanous," and its latest chamber-wall is "perforate." Its shell more abounds with sand and sandy cement than that of any other of the "hyaline" species that becomes sandy with age. In its changeable modes of growth this Foraminifer carries us into *Trochammina* on one hand, with resemblances of *Lituola* and other forms, and into *Bulimina* (another sandy "Hyaline"), on the other. Its tongue-like valve in the aperture is, however, peculiar, and distinguishes its imitative forms from their apparent allies, such as *Bulimina* and, when elongate, *Bigenerina*.

3. (I.) The "Hyaline" or "Perforate" Foraminifera, have one set of forms that may be grouped around *Lagena*, and have been denominated the "Family *Lagenida*," (Carpenter's "Introd., &c., p. 156). *Lagena*, *Nodosarina*, *Orthocerina*, *Polymorphina*, and *Uvigerina*, are the generic forms—and indeed the last two are not clearly distinct—nor is there any very essential difference zoologically between the others. Under the term *Nodosarina* are grouped a varied assemblage, that seem at first sight distinct enough, but the gradations of shape are so perfect, and the shell-structure so uniform throughout, that the names *Nodosaria*, *Dentalina*, *Vaginulina*, *Planularia*, *Marginulina*, *Cristellaria*, and numbers of synonyms, merely record the occurrence of innumerable passage-forms from the straight to the coiled, the flat to the round, and so on, that supply endless links throughout a very wide series, remarkable for their early appearance in geologic time (in the Carboniferous, Permian, Triassic, and other formations), and their cosmopolitan character at present.

(II.) The *Globigerinida* (Carpenter's "Introd.," p. 175) comprise the *Textilarinæ*, the *Globigerinæ*, and the *Rotalinæ*. The shells are thinner, as a rule, than those of the *Nodosarinæ*, and porous rather than tubuliferous. The Nautiloid and Helicoid modes of growth, and modifications thereof, are common with the *Globigerinæ* and *Rotalinæ;* but the *Buliminæ* and *Textilariæ*, and their legion of subgenera, have alternate arrangements of segments producing plaited forms and conical shells more or less like wheat-ears, grass-flowers, and such like.

Each of the three chief groups has its monothalamous representative, or starting-point. The Eocene *Ovulites* may be associated with the *Textilarinæ;* the Triassic (?) *Orbulina* with the *Globigerinæ*, and the recent *Spirillina* with the *Rotalinæ*. Some *Textilariæ* are labyrinthic, and many become sandy with age (*Plecanium*, Reuss); and some *Buliminæ* also (*Ataxophragmium*, Reuss).

(III.) The high-class *Nummulinida* have tubuliferous shell-substance as a rule. *Nonionina* is the simplest form; it becomes complex in *Polystomella*. *Fusulina* is probably an ally of these.

Operculina is a feeble, and *Amphistegina* an asymmetrical Nummulite. *Heterostegina* has its chambers divided into chamberlets; and *Cycloclypeus* has a cyclical growth, with annuli of chamberlets. The last is to *Heterostegina* as *Orbitolites* is to *Orbiculina*. Lastly, *Orbitoides* combines a Nummuline system of chambers, with the heaped umbilical cell-growth seen in *Tinoporus* and *Patellina*.

As an attempt to indicate the real value of *Foraminifera* to Palæontologists, the accompanying *Table* of recent and fossil Foraminifera is presented to the Association. It shews, with some precision, though necessarily without perfect accuracy, the broadly marked geological formations in which the several *genera* (together with some of the more noticeable of the *subgenera*) have hitherto been found. In a strict zoological sense, a Foraminiferal *Genus* has but the value of a common *Species*, under the three several groups of Porcellanous, Arenaceous, and Hyaline, respectively, therefore such a list as this may be used side by side with lists of *Species* of higher animals, for some purposes of comparison and research.

Its imperfections mainly arise from the many still unwrought fossiliferous deposits not having been made to yield their materials for this record of past protozoan life; from occasional want of definition of the geological positions; and lastly from the difficulty in determining the relationships of some of the published Foraminifera, especially of the Rotaline forms, according to the nomenclature used in England. Even in its present state, however, the Table seems to be suggestive of much that is of interest to the Geologist.

Of the Porcellanous Foraminifera.

As far as we yet know *Nubecularia* is Rhætic in origin (taking the blue clay of Chellaston as of that age); *Miliola* is a Triassic form, and probably so is *Cornuspira*. These are all recent also; and *Miliola* is traceable in nearly all formations. *Hauerina* and *Fabularia* (near *Miliola*) are apparently extinct. *Peneroplis*, *Orbiculina*, *Alveolina*, and *Orbitolites*, relatively large forms, of compound structure, began some with the Maestricht Chalk, some with the older Tertiary deposits, and continue now. The composite *Dactylopora* and *Acicularia* are perhaps only of Tertiary age; but *Dactyloporæ* of simple construction still exist.

Of the Arenaceous Foraminifera.

The closely related *Trochammina*, *Valvulina*, *Involutina*, *Lituola*, and *Saccammina*, occur in the Carboniferous, and live now; some being well represented in every formation. The monster forms *Parkeria** (Upper Greensand), and *Loftusia* (Tertiary) came in later, and seem to be extinct.

Of the HYALINE FORAMINIFERA.

Textilaria and *Bulimina* are essentially hyaline; but, taking up sand in their shell, become arenaceous in the adult state. These began early. *Textilaria* is at least of Carboniferous, and *Bulimina* of Rhætic age. They have interminable modifications, some of which began in Cretaceous, others in Tertiary times. *Cassidulina* is only as old as the Middle Tertiaries. Nearly all live now.

The *Nodosarinæ* occur in the Carboniferous Limestone, and abound in every formation to the present day. The closely related *Polymorphina* seems to have begun its existence at a later period (Trias), and persists; whilst its offshoot, the *Uvigerina* is only of Tertiary and Recent age. *Lagena* seems to be of Devonian origin according to Ehrenberg's description of a microzoon of that date.

The essentially abyssal Foraminifera are *Orbulina*, *Globigerina*, *Pullenia*, and *Sphæroidina*, belonging to the "hyaline" division. Of these the first two (really of close alliance) began, it seems, with the Trias and Lias; and they live on now in abundance. The other two date back no further than the Chalk, as far as we yet know.

Professor Reuss's *Cryptostegia* (*Allomorphina* and *Chilostomella*) Milioline in shape, but hyaline in structure, appear to me to belong to the *Globigerinida*. They began with the Chalk, it seems. Probably some of the so-called *Biloculinæ* and *Triloculinæ* described by D'Orbigny from the Atlantic belong to this group.

The Rotaline forms of Foraminifera are very interesting, and very difficult to discriminate. Of these, *Pulvinulina* (Trias) and *Planorbulina* (Lias) are of somewhat simple structure, and have the longest pedigree; and it is well sustained by continued occurrence. *Discorbina*, *Rotalia*, *Cymbalopora*, and *Calcarina* appear with the Chalk (chiefly in that of Maestricht); *Spirillina*, a very simple form, has not been found in beds older than the Tertiaries; and all live now in abundance.

Tinoporus and *Patellina* may be said to be Cretaceous forms living on now.

As for the Nummuline species, they have representatives (not

* A fossil which is probably a *Parkeria* is known from the Carboniferous rocks of Cashmere.

yet well determined) in the Carboniferous rocks and the Oolite. *Operculina* first definitely occurs in the Lower Cretaceous of France. It is also found in the Maestricht Chalk, and has lived on till now. The better grown *Nummulina*, of which a doubtful representative has been quoted from the Hippurite Chalk of the East (Palestine), abounded in the early Tertiary period; and having struggled on through successive periods, is not extinct. Its one-sided relative, the *Amphistegina*, began in the Mid-tertiary times, and thrives still. Its thin, but widened and sub-labyrinthic allies *Heterostegina* and *Cycloclypeus* are known only in the Tertiary deposits and the existing oceans.

Orbitoides seems to have begun existence with the Maestricht Chalk, and to have died out in Mid-tertiary times.

Fusulina was thought to be confined to the Carboniferous and Permian Rocks, but Ehrenberg figures one from the Lower Oolite.

Polystomella commenced with the Maestricht Chalk, and has flourished ever since. Of its weaker form, *Nonionina*, there are doubtful specimens in the Carboniferous and Jurassic rocks; and crowds of varieties have abounded from the age of the Chalk to the present day.

Coccoliths are found in many strata (Güembel), like those of the Chalk and Recent oceans, in which they are supposed to be especially associated with *Bathybius* or with separate minute sarcodic masses called Coccospheres (Wallich and Huxley). In the Silurian there is the *Stromatopora* at least, besides obscure *Textilariæ*, and glauconitic casts of Polymorphine, Rotaline, and other forms (Ehrenberg). In the Cambrian of Bohemia, and the Laurentian of Canada, we have *Eozoon*, of as high a structure as any of the composite "hyaline" forms, in patches several square inches in size, forming together aggregations of considerable dimensions.

Thus, *Miliola* among the "Porcellanous," *Trochammina* and *Lituola* among the "Arenaceous," *Textilaria*, *Nodosarina*, *Globigerina*, *Pulvinulina*, and *Planorbulina* among the "Hyaline" Foraminifera, are the chief of the genera of longest (known) existence, that is, beginning before the Cretaceous Period, and living now.

Stromatopora and *Eozoon* appear to be essentially Palæozoic forms.

[For some notes on the preparation of clays, sands, and chalk for Microscopical purposes, see the "Geologist," vol. i., 1858, p. 249; and vol. v., 1862, p. 59. See also the "Microscopical Dictionary" (Van Voorst, London), Article CHALK, &c.]

Tabular View of the Range of Foraminifera in Time.

Group	Relation	Genera and notable Subgenera.	Recent.	Tertiary.			Cretaceous.				Jurassic.			Triassic.			
				Upper.	Middle.	Lower.	Chalk.	Upper Greensand.	Gault.	Neocomian.	Upper Oolite.	Lower Oolite.	Lias.	Rhætic.	Trias.	Permian.	Carboniferous.
Porcellanous Foraminifera.	Allied. Allies.	Squamulina	*	*													
		Cornuspira	*	*	*	*	...	...	...	...	...	?	...	...	?		
		Nubecularia	*	...	...	...	...	...	...	...	...	*	...	*			
	Allied. Allies.	Vertebralina	*	...	*	*											
		Miliola	*	*	*	*	*	...	*	...	*	...	*	...	*		
		Hauerina	...	...	*	...	...	...	*								
		Fabularia	...	...	...	*											
	Allies.	Peneroplis	*	...	*	*											
		Orbiculina	*	...	*												
		Orbitolites	*	...	...	*	*										
		Alveolina	*	...	*	*	?										
	Allies.	Dactylopora	*	...	*	*											
		Acicularia	...	...	*	*											
Arenaceous Foraminifera.	Allies.	Parkeria	...	...	...	...	...	*	...	...	...	...	...	...	...	...	?
		Loftusia	...	...	...	*											
	Allies.	Involutina	...	...	...	...	...	...	...	...	...	*	*	...	...	...	*
		Trochammina	*	*	*	*	*	...	*	...	*	*	*	...	*	*	?
		Webbina	*	*	...	...	...	...	...	*	...	*	*	*			
		Saccammina	*	...	...	...	...	...	...	...	...	?	*	...	...	...	*
		Lituola	*	*	*	*	*	...	*	*	...	*	*	*	...	...	?
		Valvulina	*	...	*	*	*	...	...	...	...	...	...	...	...	...	*
Hyaline Foraminifera.	Allied.	Ellipsoidina	...	*													
		Lagena	*	*	*	*	*	...	*	...	*	*	?				
	Allied. One Genus-Nodosarina.	Nodosaria	*	*	*	*	*	?	*	*	*	*	*	*	*	*	*
		Dentalina	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
		Lingulina	*	*	*	*	*	...	*	...	...	...	*	*	*		
		Orthocerina	*	?	*	*	*	...	*	...	*						
		Vaginulina	*	*	*	*	*	...	*	*	*	*	*	*			
		Marginulina	*	*	*	*	*	...	*	*	*	*	*	...	*		
		Cristellaria	*	*	*	*	*	*	*	*	*	*	*	*	*	...	?
		Planularia	*	*	*	*	*	...	...	*	*	?	*	*	*		
		Flabellina	...	...	*	*	*	...	...	...	...	?	*	*			
		Frondicularia	*	*	*	*	*	...	*	...	*	...	*	*			
	Allies. Allied.	Polymorphina	*	*	*	*	*	*	*	...	*	...	*	*	*		
		Uvigerina	*	?	*	*											
	Allies. Allied.	Bulimina	*	*	*	*	*	*	*	...	*	...	...	*			
		Cassidulina	*	*	*												
	Allies. One Genus.	Textilaria	*	*	*	*	*	?	*	*	*	?	*	*	*	*	*
		Verneuilina	*	?	*	*	*										
		Chrysalidina	*	...	...	...	*										
		Cuneolina	...	...	...	...	*										
		Ovulites	...	...	*	*											
	Allied.	Orbulina	*	*	*	...	*	...	...	...	*	...	*				
		Globigerina	*	*	*	*	*	...	*	...	...	...	...	...	*		

TABULAR VIEW OF THE RANGE OF FORAMINIFERA IN TIME—*(continued.)*

	GENERA and notable SUBGENERA.	Recent.	Tertiary. Upper.	Tertiary. Middle	Tertiary. Lower.	Cretaceous. Chalk.	Cretaceous. Upper Greensand.	Cretaceous. Gault.	Cretaceous. Neocomian.	Jurassic. Upper Oolite.	Jurassic. Lower Oolite.	Jurassic. Lias.	Triassic. Rhætic.	Triassic. Trias	Permian.	Carboniferous.
HYALINE FORAMINIFERA. Allied.	Pullenia	*	?	*	*	*										
HYALINE FORAMINIFERA. Allied.	Sphæroidina	*	?	*	*	*										
HYALINE FORAMINIFERA. Allied.	Allomorphina	...	...	*	*	*										
HYALINE FORAMINIFERA. Allied.	Chilostomella	...	...	*	*											
HYALINE FORAMINIFERA.	Carpenteria	*	...	...	...	?	?	...	...	?						
HYALINE FORAMINIFERA. Rotalinæ Subfamily. Helicoid Forms.	Spirillina	*	*	?	*											
HYALINE FORAMINIFERA. Rotalinæ Subfamily. Helicoid Forms.	Discorbina	*	*	*	*	*										
HYALINE FORAMINIFERA. Rotalinæ Subfamily. Helicoid Forms.	Planorbulina	*	*	*	*	*	*	*	...	*	*	*				
HYALINE FORAMINIFERA. Rotalinæ Subfamily. Helicoid Forms.	Pulvinulina	*	*	*	*	*	...	*	...	*	*	*	*			
HYALINE FORAMINIFERA. Rotalinæ Subfamily. Helicoid Forms.	Rotalia	*	*	*	*	*										
HYALINE FORAMINIFERA. Rotalinæ Subfamily. Helicoid Forms.	Cymbalopora	*	...	*	...	*										
HYALINE FORAMINIFERA. Rotalinæ Subfamily. Helicoid Forms.	Calcarina	*	*	*	*	*										
HYALINE FORAMINIFERA. Rotalinæ Subfamily.	Tinoporus	*	*	*	*	*	?									
HYALINE FORAMINIFERA. Rotalinæ Subfamily.	Patellina	*	...	...	*	*	*									
HYALINE FORAMINIFERA. Rotalinæ Subfamily.	Polytrema	*														
HYALINE FORAMINIFERA. One Genus.	Polystomella	*	*	*	*	*										
HYALINE FORAMINIFERA. One Genus.	Nonionina	*	*	*	*	*	...	...	...	?	...	...	...	...	...	?
HYALINE FORAMINIFERA. One Genus.	Operculina	*	*	*	*	*	...	...	*							
HYALINE FORAMINIFERA. One Genus.	Nummulina	*	*	*	*	?	...	...	...	?						
HYALINE FORAMINIFERA. One Genus.	Orobias	...	...	...	...	...	...	...	...	...	...	...	...	...	...	*
HYALINE FORAMINIFERA.	Amphistegina	*	*	*												
HYALINE FORAMINIFERA.	Heterostegina	*	...	*	*											
HYALINE FORAMINIFERA.	Cycloclypeus	*	...	*												
HYALINE FORAMINIFERA.	Orbitoides	...	...	*	*	*										
HYALINE FORAMINIFERA.	Fusulina	...	...	...	...	...	...	...	...	...	*	...	...	...	*	*

VISIT TO THE BRITISH MUSEUM,

MARCH 18TH, 1871.

Directors—Professor MORRIS, F.G.S., WILLIAM CARRUTHERS, Esq., F.L.S., F.G.S., and HENRY WOODWARD, Esq., F.G.S., F.Z.S.

The Members, on assembling at the Museum, proceeded to the Botanical Department, where Mr. Carruthers described those portions of the Collection most interesting to geologists, and pointed out the characters of the Ferns, the Palms, the Cycads, and the Coniferæ. Some exceedingly beautiful sections mounted on glass and exhibiting in a remarkably striking manner vegetable structure were shown. The fossil Cycads from the Purbeck of the Island of Portland, and the fossil fruits from the London Clay of the Isle of Sheppy, attracted special attention. Passing to the North Gallery, the fossil plants from the Coal Measures were succinctly described by Mr. Carruthers, who concluded his lecture by a notice of the dicotyledonous leaves which have been so abundantly obtained from Miocene strata.

Mr. Henry Woodward then conducted the visitors to the Collections of Fossil Reptilia, and described the more remarkable of the Saurian remains here exhibited. Subsequently the *Pterodactyles*, the *Archæopterix*, and the *Dinornis*, were brought under the notice of the Members, and their distinguishing characters recapitulated. The impressions of the feathers of the *Archæopterix* on the Solenhofen lithographic stone were observed with great interest, as were also some enormous sub-fossil eggs, one of which measures upwards of thirty inches in circumference.

The Members now proceeded to the Department of Fossil Mammalia. Here Professor Morris delivered a lecture on the geographical distribution of the larger animals, and showed that in the latest geological deposits the orders, if not the genera, were the same as those now inhabiting the same zoological provinces of the globe. The Professor's lecture was illustrated by the fine specimens in this portion of the Museum.

The lectures were listened to with great interest, and the thanks of the Members present were cordially given to Mr. Carruthers, Mr. Henry Woodward, and Professor Morris.

VISIT TO THE MUSEUM OF PRACTICAL GEOLOGY, JERMYN STREET, March 25th, 1871.

Directors—Professor Morris, F.G.S., Professor Tennant, F.G.S., and Robert Etheridge, Esq., F.G.S.

Mr. Etheridge conducted the Members through the galleries of the Museum, in which are displayed the Palæontological Collections, and described the arrangement adopted and subsequently the contents of the cases. The fossils in this Museum are arranged stratigraphically. The student is thus afforded a ready means of making himself acquainted with the organic contents of any group of strata which he may be specially studying. In the lower of the two galleries are displayed the Palæozoic fossils, and in the upper gallery the Mesozoic and Cainozoic species are to be found.

The attention of the Members was directed to the more important and remarkable fossils, and the general characters of the fauna of each geological formation were pointed out.

At the termination of Mr. Etheridge's descriptive lecture, the Mineralogical Department, which occupies the principal floor of the Museum was visited, when Professor Tennant described the non-metallic minerals exhibited in the great horse-shoe case. Some of the specimens are extremely fine, and all are very distinctly shown and conspicuously labelled, thus rendering the collection of great value to the student.

The party next assembled in the room devoted to the illustration of Coal-mining, where Professor Morris delivered a most instructive lecture on Coal and Coal-mining, in the course of which he explained the elaborate and beautiful models and sections in this portion of the Museum, which afford so much assistance to the student of Practical Geology.

Votes of thanks were heartily accorded to Mr. Etheridge, Professor Tennant and Professor Morris, for their valuable lectures and able guidance, and this very interesting and instructive visit then terminated.

ORDINARY MEETING, April 4th, 1871.

The Rev. Thomas Wiltshire, M.A., F.G.S., &c., President, in the Chair.

The following Donations were announced :—

" Abstracts of Proceedings of the Geological Society," from that Society.

" Journal of the London Institution," from that Institution.

" On the Denudations of Norfolk," by the Rev. Osmond Fisher, M.A., F.G.S., from the Author.

" On the Coprolite Pits of Cambridgeshire," by the Rev. Osmond Fisher, M.A., F.G.S., from the Author.

The following were elected members of the Association :—

W. Phipson Beale, Esq., F.G.S., F.C.S.; William Henry Corfield, Esq., M.A., M.B., F.G.S., F.C.S., Fellow of Pembroke College, Oxford, Professor of Hygiene in University College, London; F. G. Hylton Price, Esq., F.R.G.S., M.A.I.; and Charles Westendarp, Esq.

The following Papers were read :—

1. On the English Crags and the Stratigraphical Divisions indicated by their Invertebrate Fauna.*

By Alfred and Robert Bell.

For some years the divisions originally proposed for the Pliocene strata in England were accepted without question, but in process of time it began to be doubted whether the Norwich, or Fluvio-marine

* Since this paper was read, so much fresh information has been obtained from various sources in support of the propositions laid down, that I have found it necessary to revise and amplify it, incorporating in it the latest results obtained by my brother and myself. None of our views have been altered in this revised paper.—Alfred Bell.

Crag could be considered as being newer than the adjacent Red Crags, which latter had never been found underlying it. From the first the superposition of the Red Crag upon the older Coralline was admitted to be an indisputable fact.

Still later, the peculiar sub-divisions or groups known as the Chillesford Sands and Clays were discovered by Mr. Prestwich, and, till the paper referred to below was read before the Geological Society of London, these divisions, *i.e.*, the Coralline, Red, and Norwich, or Fluvio-marine Crags, and the Chillesford Sands and Clays, were considered to be the horizons indicated both by the palæontological and physical phenomena. In this memoir, Mr. Prestwich has reduced the formations to two, the Lower being the Coralline Crag, and the Upper, or Red Crag, composed of all the strata hitherto grouped as the Red Crag, the Norwich Crag, and the Chillesford Series, the last-named forming the upper division. As regards the fauna, especially the Mollusca, many of the shells in the Red Crag were considered to be derived from the waste of the older Coralline ;—thus reducing the species of the Upper Crags to a greater homogeneity in *facies*.

Having carefully tabulated for some years past the fossils from different localities in this district, we were constrained to differ from the conclusions arrived at by the writer, as our results did not coincide with his ; and we proposed the following arrangement and nomenclature for the deposits in question, dissenting from the ordinary terms employed, as not being explicit enough, and being, moreover, calculated to mislead the enquirer, the colour not being confined to one group, nor the local conditions (fluvio-marine) to another.

We allotted the horizons, thus :—

Preglacial, or Chillesford Series, comprising the Chillesford Sands and Clays, and the Forest and Elephant Beds of the coast.

Upper Crag.—The Fluvio-marine of Norfolk and Suffolk, and such part of the Red Crag as will be hereafter indicated.

Middle.—The older Red Crag, including its extension into Essex; and the

Lower, or Coralline Crag.

Our chief calculations were based upon the Mollusca, but not exclusively. The annexed table gives the nett total of the organic remains at present known to us :—

SUMMARY.	Lower Crag.	Middle Crag.	Upper Crag.	Chillesford Crag.	Forest Bed.
Terrestrial Mammalia...	5	19	18	4	36
Marine Mammalia	4	24	3	2	3
Aves	1	...	1	...	...
Pisces	13	9 ?	6	2	2
Insecta	...	...	...	...	2
Crustacea (Excl. Entom. & Cir.)	9	2	1	1	...
Entomostraca	18	4	...	...	...
Cirripedia	9	9	6	3	...
Annelida	12	4	3	2	...
Echinodermata	17	13	3	3	...
Land and Fresh Water Mollusca	...	3	27	11	36
Marine Gasteropoda and Solenoconcha	200	198	150	52	...
Opisthobranchiata	16	6	5	4	...
Pteropoda	1	...	...	...	...
Lamellibranchiata	169	149	96	74	...
Brachiopoda ...	5	1	3	...	...
Polyzoa ...	125	47	5	3	...
Cœlenterata ...	3	5	2	...	...
Spongida...	1	2	...	...	...
Foraminifera...	97	20	10	5	...
Plantæ ...	2	1	...	1	15
Total of each formation	707	516	339	167	94

Before entering upon the description of the Crags, we would remark that we were and are still of opinion "that a well defined variety, one easily recognisable, and accepted as a distinct species by the majority of naturalists, or even one that is the characteristic form in other seas or formations, is of as much value, both geologically and palæontologically, as a specific type." The necessity for this is easily seen. *Tellina Benedenii, T. obliqua*, and *T. prætenuis* have been considered as varieties of *T. calcarea.* All these precede the type in time, and are all extinct, but the latter is a plentiful form in Northern Seas of the present day. Under such circumstances to remove them from our lists (as being only varieties) would be manifestly unsafe. This is but one example. *Purpura tetragona* is another.

Another question that has been raised is, what species, and how many, are derived from the destruction of the older beds. In the Red Crag, amongst the shells, Mr. Wood considers 25, Mr. Prestwich 46, and Mr. Jeffreys 13 species to come into this class; but for ourselves we came to the conclusion that, while some individual specimens might be extraneous, there was not sufficient evidence to justify the removal of an entire species from this formation*—but this point we shall dwell upon more at large hereafter.

The elevation of the sea bed in the southern part of the area (that which now constitutes the present German Ocean), resulted in the formation of a deep and quiet gulf, teeming with life, especially rich in shells and Echini, the deposits formed on the western side of this gulf now constituting the Coralline or Lower Crag, but between the life of this Crag sea and that of the earlier Diestien one a great difference obtained, indicating considerable changes, and a lapse of time during which many alterations took place, several genera of the more southern types disappearing, such as *Conus*, *Oliva*, *Pseudoliva*, and *Ancillaria*.

As defined by Mr. Charlesworth, the area (including outliers) of the Lower Crag extends from Aldborough to Tattingstone. How far eastward the gulf extended cannot be told, but from the absence of this formation in Belgium and Holland, and the direct superposition of the "Sables Gris" upon the Diestien Sands, it is probable that the line of the Belgian sea coast was more out to sea than it is at present.

The most prominent exposures of the Lower Crag are in the neighbourhoods of Aldborough and Orford, and in Sutton and Ramsholt parishes. Nearly all these deposits are slightly diversified in their fauna, according to the depths at which they were formed.

Like the succeeding horizon (Middle Crag), the base of this Crag consists of a layer of nodules or "box stones," coprolites, London Clay fossils, bones, teeth, and vertebræ of various animals,† terrestrial and marine, succeeded by bands of marly sands, containing large molluscs. These bands yield *Cassidaria*, *Pyrula*, *Voluta*, *Triton*, *Ovula*, *Buccinopsis*, *Panopæa*, *Ostrea*, *Cyprina*, *Cardita*, *Pecten (maximus)*, *Terebratula*, and others, also *Echinus Woodwardii*, *Balanus concavus*, and *Flabellum Woodii*, in tolerable abundance. Unfortunately they are seldom exposed. Next come sands containing the smaller Mollusca, as at Gedgrave. These are plentifully intermixed with small Polyzoa at Sutton. In Sudbourn Park, at Aldborough, and at Sutton, the upper members of the

* Except those derived from the Black Sands. See p. 190.

† Prestwich, "Quart. Journ. Geol. Soc.," Vol. xxvii., p. 117.

series consist of sands and broken shells, in some places consolidated into a close hard building stone, containing Echini and Crustacea.

The thickness of the entire series has been variously estimated from 40 feet (Wood) to 80 feet (Prestwich). Some of the beds in the memoir just cited appear to be concurrent, owing their difference in structure and contents to local conditions only.

Cetacean remains of large size are not uncommon in the Lower Crag, also teeth and ear bones, belonging to various species of sharks and other fishes, mostly gadoids.*

Whether the terrestrial Vertebrata found associated with them are of the same age is an open question; we cannot see any objection to their being considered so.† A land fauna there must have been, and the animal types must have approached very closely those which have been found. A slender limb bone of a small deer and another of a bird were obtained by Colonel Alexander, from Orford, and are unmistakably non-derived. It is a singular circumstance that while the greater number of the Echini, Corals, Polyzoa, and Entomostraca are extinct, more than half the shells and Cirripedia and the whole of the Crustacea called by Professor Huxley the Podopthalmia, are recent.

As bearing upon the depth of the Crag Sea, it may be noticed that most of the forms of the Mollusca which the recent deep-sea dredgings have proved to be living and not extinct as supposed, were only found at very great depths.

In descending order the several zones of the Lower Crag appear to be characterised by the following Echini:—

1. *Spatangus purpureus.*
2. *Temnechini* of various species, *Echinus sphæra*, *Echinocyamus*, 2 sp.
3. *Spatangus regina*, *Brissus*, *Amphidetus*, and *Echinus Woodwardi.*

The Mollusca are very pure; we are not aware of a single species, which, like some of the Middle Crag forms, can be considered derived from an older bed, whether Diestien or Eocene. A few fossils of older date are occasionally found. We obtained a fine unrolled Neocomien Ammonite, six inches across, from Sudbourn Park, imbedded amongst the Polyzoa.

The original object of this paper was to show, that contrary to

* The presence of the whale barnacle (*Coronula barbata*) in the Middle Crag is sufficient to prove the Cetacea integral parts of that fauna, as it *only* lives embedded in the animal's skin.

† These remarks also apply to the Mammalian remains in the succeeding group.

the opinion held by many that the fauna of the Red Crag was indivisible, and that no difference could be substantiated in the layers of strata forming this deposit, and that of the adjacent Fluvio-marine Crag, it was *possible* to define very sharply the line of demarcation, and this we shall now endeavour to do, first dismissing the question of derivation.

In this section of the Crag many extraneous fossils occur, and they serve a very useful purpose. Amongst them may be stated to be the so called coprolites (nodules of phosphatic clay frequently enveloping an Eocene organism), the "box stones" of Diestien age, mammals, crustaceans, fishes, shells (a few), and other remains, both of Secondary and Tertiary (Eocene) age. Mixed with them are a few shells of the Belgian Black Sands, and five or six species of plants.*

The value of these remains in determining the horizons of the Crag is very great. They abound (except the Black Sand shells) in the Lower Crag, and also in the Middle, but in the Upper Crag they are rarely found. They also appear to have been chiefly deposited in deep water, the shallower deposit at Walton-on-the-Naze containing very few examples of this class. It is not, however, so much with these as with the fossils of the preceding Coralline Crag that the question has to do. It has been asserted, with very great force and probability, that as the soft rock of the Lower Crag was subjected to considerable erosion by the wash of the Red Crag sea, necessarily many of the remains imbedded therein must have passed into and become intermingled with those organisms that were then living in and on the sandy bottom of the sea and its shores. This argument is also supported by the worn appearance of the remains. The Walton-on-the-Naze deposit was considered for a long time as *the* typical undisturbed sea bed in which the fossils were undoubtedly native, the bivalves being frequently found in pairs, the univalves with the most delicate part, the apex (the first portion to go in any rolled specimen and frequently lost in the life time of the animal) uninjured. Colour, scarcity, and badness of condition are also suggested as indicative of derivative origin.

Accepting Walton-Naze as a typical deposit, we noticed first, that our lists contain altogether 170 shells from this locality, 116 being common to the older Crag. Secondly, that many species of

* The Middle Crag plants are given on the authority of Mr. Carruthers, of the British Museum.

bivalves occur double and *in situ*, not only at Walton, but also at Sutton, Foxhall, Waldringfield, Shottisham, Ramsholt, Bawdsey, and, indeed, nearly everywhere else, at various times, not in single specimens but in dozens, and even in hundreds.

The most striking testimony to the non-derivation of the Brachiopoda is in their situation. They are almost invariably, like many of their congeners of the present day, grouped around, or in the vicinity of large stones, to which they had probably been attached during life.

Again, many of the species differ in many points from their fellows in the Lower deposit. *Cardita senilis* loses much of its beauty of form in the higher Crag, being coarser in texture and build, and frequently much larger; and the *Terebratula* is an example of a variety which does not occur at all in the Lower Crag.

Perfection in the univalves is by no means confined to Walton. Many of the most beautiful specimens we have seen come from other localities, especially in the genera *Cassidaria*, *Pyrula*, *Cancellaria*, *Fusus*, *Emarginula*, *Scalaria*, and *Ovula*.

The worn condition of many specimens does not avail in a question of this kind. Nearly any sea coast will furnish such examples in plenty, and also many single valves. Broken and worn examples are still more plentiful in dredgings taken below low water mark. The peculiar nature of the matrix really has more to do with the condition of the shells than anything else, decortication being a common feature in these beds.

It would be reasonable to expect that if a fauna was in any part derived, the best evidence would be obtained where the faunas meet, that is to say, where the two deposits adjoin. We shall have occasion to notice presently a very striking example of this kind. We refer to the well-known outlier of Coralline Crag at Sutton, where we believe the whole question of the succession of the Crags is to be wrought out. At present it will be sufficient to say that, neither in the pit in the Bullock-yard, * or in the pit on the opposite side of Coralline Crag Hill,† are to be found many of the commonest fossils of the Lower Crag, upon which the seas of a later time beat. Were the fossils of the Upper Crags derived, here we ought to find good and sufficient evidence; but in the absence of such evidence we contend that the theory of derivation is untenable, as being based upon insufficient grounds.

* Prestwich, "Quart. Journ. Geol. Soc.," vol. xxvii. Pl. VI., Fig. I., Pit D.
† Idem, Pit G.

The stratification of the Crag in this horizon is exceedingly indefinite, false bedding and oblique lamination being the rule; horizontal layers seldom occurring. The false bedding is probably due to the many changes produced by local shifting currents and sand banks, and the oblique laminations may perhaps partially mark the slopes of the sea bottom.

The distribution of life in this sea was to all appearance similar to that in the present. If a great and wide reconstruction of the sea-bed had taken place, we should find that the organisms were much more intermixed than they appear to be. According to local conditions either of depth, soil, nature of feeding grounds, shelter, &c., so the distribution varies.

The Brachiopoda are, as before mentioned, in groups larger or smaller, and vary in length from a quarter to three inches. The *Gastranæ* and *Myæ* are imbedded in sandy mud, siphonal ends uppermost; the *Pholades* and *Saxicavidæ* in their cells, as at Waldringfield and Foxhall;—at the Sutton pit G. (see Prestwich, op. cit.), the latter are free in the sand. It is not at all uncommon to find the cavities occupied by two or more individuals, as if when one animal had died another made use of the accommodation already provided for him. *Kellia*, *Tapes*, and *Modiolaria* are the genera mostly found in these appropriated tenements. The mussels and cockles are end up side by side, or closely packed in their several places, with the more solitary species interspersed amongst them. In this state are the Rock Oyster and *Pecten maximus* found. Very rarely the large *Panopæa* and *Lutraria* are obtained. Univalves are less gregarious, but even these are grouped, though perhaps irregularly; and it is remarkable that many forms are peculiar to different localities. *Purpura tetragona* is abundant at Walton, but less so elsewhere. *Fusus contrarius*, and *Fusus antiquus* each have their several haunts, and so it is with many other species.

Occasionally the shells are heaped up without order; broken univalves, parted bivalves, and comminuted fragments of all classes of the animal kingdom abounding. At Walton-Naze, Shottisham Creek, Ramsholt, and Butley, the shells are better preserved and more assorted. Walton particularly has its beds of *Pectunculus*, *Artemis*, *Mactra*, and another (rarely found) that may be called the *Actæon* and *Echinus* bed. These occur in the order given, the *Pectunculus* band being the lowest.

The area occupied by the Newer (*i. e.*, Middle and Upper) Crags is of considerable extent. In the south its outliers are at Walton-

Naze and Beaumont, in Essex, the main mass stretching from the north side of the Orwell to Tattingstone and Bentley; on the north it is more irregular, comprehending the beds known as the Fluvio-marine Crag of "Thorpe and Bramerton, Wangford Bulchamp and Thorpe near Aldborough" (Wood and Harmer).

This area is more or less three hundred square miles in extent, and it is a disputed question as to whether the strata in this district is one homogenous deposit, the organic changes in which are simply due to lapse of time and climatic changes; or if, on the other hand, two distinct periods are indicated either by their physical conditions or palæontological contents. We contend for the latter, but many far better known geologists than ourselves incline to the former view.

In working out this point, we adopted the following plan, viz., the keeping a record of the fauna yielded by certain pits and sections. These comprised Walton-on-the-Naze, Waldringfield, Sutton (Pits D and G of Mr. Prestwich's plan), Butley Neutral Farm pit, Butley Mill and the Chillesford Stack-yard pits, and others less persistently examined at Bentley, Bawdsey, Felixstow, Shottisham, Butley Abbey, and also other pits in the Norwich Fluvio-marine Crag localities, our collections embracing everything we could find. On collating these lists, we found that in the Red Crag two distinct groups were indicated—the older characterised by the great abundance of its coprolites, its mammalian fauna, the presence of London Clay fossils, and, above all, by the great number of forms held in common in this and the Lower Crag. At Walton-on-the-Naze alone, out of 170 shells 116 are common to the Coralline Crag, as just stated, and this is in a section which is generally allowed to be a typical one containing a typical fauna.

The Upper division is chiefly noticeable for the absence of the mammalian fauna (in its marine aspect), coprolites, box stones, and Eocene fossils, for the few species that are extinct, and for the great abundance of northern and Arctic forms, agreeing in this respect with the Fluvio-marine Crags, nearly every species of which (except some of the land and freshwater shells) is found in the Newer or Upper Red Crag.

We further found that each horizon had its aspects of deep and shallow water, and this appeared to us to explain much of the discrepancy in the faunas of the different localities. The deepest water of the older (our Middle) Crag sea was in the Waldringfield, Sutton, and Shottisham districts, and the shallowest at

Walton-on-the-Naze. Waldringfield and Sutton are distinguished by their *Terebratula* and corals, Shottisham by its fine shells and Polyzoa. Walton-Naze containing but few box stones, only a few worn Brachiopods (single valves), with a general absence of the deeper water forms.

In the Upper division occurred another Brachiopod (*Rhynchonella psittacea*), a small group of three specimens and an odd valve in close proximity to a large stone; *Fusus Largilliertii*, *F. Turtoni*, a very large *Natica* (? sp. indet), and a few Polyzoa and corals of the same species as in the lower group (*Flabellum* excepted), but of much smaller size.

The recent deep-sea dredgings have shown that deep-sea life is more persistent in time than that of shallow water. This is in favour of our argument, because the greatest number of forms common to the horizons of the Middle and Upper Crags, are found in the deep sea zones. The shallower deposits of Walton-Naze and Butley are widely apart in their fauna.

This appears very much in the Echini, most of the Walton species being extinct, while those of Butley are recent. Of the twelve species of Radiata two only are common to both horizons. A study of the lists at the end of this paper will shew the species proper to each division; and we need only notice here the peculiarity of facies connected with each division. Thus, the older indicates a warm and genial climate, similar to that of Southern Europe. *Ostrea cochlear*, *Lima inflata*, *Modiolaria*, *Petagnæ*, *Limopsis aurita*, *L. pygmæa*, *Chama gryphoides*, *Isocardia cor*, *Venus chione*, *Lucinopsis Lajonkairii*, *Tapes texturata*, and *Mactra glauca*, amongst the bivalves, and *Cancellaria*, *Pyrula*, *Nassa prismatica*, *Pleurotoma lævigata*, *P. carinata*, *Mitra ebenus*, *Ovula*, *Vermetus glomeratus*, *V. triquetra*, *Dentalium rectum*, in the univalves, being good evidence in favour of this supposition.

In the newer horizon the characteristic shells are *Cardium Greenlandicum*, *Leda hyperborea*, *L. myalis*, *Acila Lyallii*, *Fusus Largillierti*, *F. Turtoni*, *Pleurotoma bicarinata*, *Columbella avara*, *Amaura candida*, *Natica borealis*, *N. occlusa*, and others equally northern in their distribution.

The difference is equally apparent in species common to the two deposits. Though common to both, their distribution is very unequal. Many forms, such as *Murex tortuosus*, *Acila Cobboldæ*, *Leda lanceolata*, *Tellina lata*, &c., are abundant in the one horizon, and represented by individuals only in the other.

There does not appear to be any decided reasons why the mammalian fauna should be relegated to a greater antiquity than the beds in which they are found, and we do not think that any advantage is gained to science by raising the question, it being one that is practically unsolveable.

Before leaving this part of the subject, we would call attention to the fauna of the other side of the Crag Gulf. Between our own Coralline and Red Crags a great hiatus occurs in the faunas, but on referring to Nyst's list from the "Sables Gris" it will be seen that a number of species which we consider typical of the individual Crags are associated together, and help to bridge over the interval. These sands may indicate a change in the sea bottom brought about in this way. Suppose that when the Lower (Coralline) Crag was being elevated the Belgian area was being depressed, till the relative positions of land and water were reversed. The "Sables Gris" being deposited in this depression, the slow re-submergence of the Corralline Crag would first permit the Pholas to form its crypts between high and low water mark, till, when deep enough, the Cetacea, so common in the oldest Red Crag, and the Belgian "Sables Jaunâtres," which overlie the "Sables Gris," would roam in and about the reefs and coast lines thus produced.

The Middle Crag was not traced by us further north than Hollesly and Butley Abbey, and generally speaking, is not seen to be overlaid by the Upper Crag, as before mentioned, and the great objection to the Norwich Crag being considered newer than the Red was chiefly owing to the fact that instances of superposition were unknown. We are still unable to speak authoritatively on this head, nevertheless an endeavour will presently be made to show that this super-position does obtain.

Returning to the structure of the Red Crags at Walton and Waldringfield, the oldest or basal portion is a zone of nearly pure sand, containing double bivalves of species, some differing from those of the Coralline Crag, others agreeing. This at Waldringfield is succeeded by the coprolitic beds, with their various anomalous contents.

As in other parts of the Red Crag district, the matrix is composed of sands and clays, full of comminuted material, and largely coloured by hydrous peroxide. The presence of this staining principle is occasionally manifest in both the Coralline and Fluvio-marine Crags, and is not unfrequently absent in the so-called Red

Crag, and this uncertainty has caused much of the perplexity in determining the age of some of the deposits.

In the Upper Crags the presence of fresh-water and estuarine conditions is indicated by the abundance of fresh-water and land animals and shells. The Norwich geologists have disinterred many species (see lists), amongst others, the common fox, otter, beaver, and water-rat, the pike, the common seal, a whale or two, and traces of birds. The fauna begins to alter at Butley, *Scrobicularia* coming in in abundance at Chillesford and Tunstall, becoming more marine again across the Iken ridge at Thorpe, and reverting to its estuarine state at Bramerton and further north.

It is on the shores of the Deben River that the changes in the fauna are most apparent, and the division of the Red Crag into two groups most clearly shown, and this we shall now refer to, using Mr. Prestwich's plan of the district round the elevation of Coralline Crag, termed by him Coralline Crag Hill. This point is selected for illustration chiefly because it is the only place we know of where the Lower, Middle, and Upper Crags are in apposition, and so well defined.

The central elevation or hill is composed of the upper beds of Coralline Crag, resting upon a wide-spreading base of the lower zones, with large shells and *Balani*, subtending from the face of the cliff to the River Deben, forming its bed wholly or partially, and extending for some distance on each side of the cliff. This elevation has an irregularly oval shape, with one end sloping obliquely to the river, and against it rests *two* separate and distinct sections of a Red Crag on the same level, but *not* connected by any intermediate patches.

On the side of the hill furthest from the river is the well-known pit in the Bullock Yard, the fossils of which agree with those of the adjacent pits on the same side of the hill. At the corner of the hill, and round the river face, are the fine sandy small shell and Echini beds. Next is a face of very hard indurated Coralline Crag, highly coloured, and cemented by an infiltration of iron. This contains large Echini, *Spatangus* for the most part. Then follows another pit (G), and, lastly, a (now filled in) pit sunk into the Coralline Crag in search of the coprolite. In the paper so often referred to, these two Red Crag pits are treated as of one stage, but our own observations point to the contrary.

We have just stated that there are no indications that the two pits are of one age, except that they occur on the same level, Coralline

Crag, both in the face of the hill and from its base to the river, being the surface rock. This of itself would signify nothing, because, if the Red Crag had originally wrapped round the older islet, the same sea which gave the hill its present form might have scarped the whole face of the cliff, leaving these two pits as memorials of a former condition;. yet, taken into connection with the life bearings of the separate pits, the conclusion appears to be obvious that they are of different ages.

To demonstrate this a short list of the fossils peculiar to each pit is given, excluding any of which even only single specimens have been found common to both. We may notice, however, one great peculiarity, viz., that in the one pit the *sinistral* form of *Fusus antiquus* is the rule, and the *dextral* form in the other. The older list includes a few of the fossils from the closely-adjoining Sutton coprolite pits, as well as from pit D. The difference between the faunas, as a whole, will be seen in the full lists at the end.

BULLOCK YARD PIT.

Temnechinus turbinatus.	Fusus consociale.
Echinarachnius Woodii?	,, elegans.
Ostrea princeps.	Buccinum glaciale.
Pecten Westendorpianus.	Desmoulea conglobata.
Hinnites giganteus.	Pleurotoma intorta.
Limopsis aurita.	Natica cirriformis.
Chama gryphoides.	,, helicina.
Lucinopsis Lajonkairiana.	Trochus granosus.
Tellina Benedenii.	Emarginula crassa.
Donax politus.	Fissurella costaria.
Panopea faujasii.	Brocchia partim-sinuosa.
Glycimeris angusta.	Scaphander lignarius.
Pholas cylindrica.	Cryptangia Woodii.
Fusus alveolatus.	Flabellum Woodii or *N. Sp.*

RIVER SIDE PIT (PIT G).

Rhynchonella psittacea.	Pleurotoma arctica.
Fusus Largilliertii.	Natica duplicata (?)
,, Turtoni.	,, occlusa.
Buccinum ciliatum.	,, Greenlandica.
Pleurotoma exarata.	,, Alderi.
,, striolata.	

A slight examination of these different lists will show that something more than an interval of space is required to account for the difference. It will be observed that while in the one case many of the organisms are either southern or extinct species, those in the other are northern or recent. Again, the matrices of the two pits seem to differ in the arrangement. In one, the oldest, the sand is coarser, and comminution greater than in the other, which possesses the aspect of an undisturbed deposit, the layers being more or less horizontal with the fossils disposed in successive planes. It is perhaps unnecessary to notice the great difference in the size of the species common to both pits.

To the right of this last pit occurs, in the parish of Ramsholt, a very instructive section, which, as given by Mr. Prestwich, represents a cliff of Red Crag, resting upon and overlying which are newer beds, having at the bottom a seam of phosphatic nodules. This section, which shows the line of erosion (vide Fig. 6, p. 237, op. cit.) very strongly, appears to present an instance in which the newer Crag beds overlie the older. Further away still, in the cliffs of Bawdsey, the newer beds are apparently similarly disposed, the Phosphatic-bed occurring inland, but not to our knowledge in the cliff. The fossils belong to the higher zone, as far as can be gathered from Mr. Prestwich's lists and our own observations.

Our own opinion of the Coralline Hill beds is, that at the time when the Bullock Yard, Sutton, Shottisham, and Waldringfield Crags were being deposited the trend of the Coralline Crag cliff was further westward than now, because in a field lying to the west of the hill, below the surface soil, the line of demarcation between the two Crags is strongly marked, as if the Red Crag had been originally continuous from the Bullock Yard in this direction, being beyond the boundary line the surface rock, whilst between this line and the pit of newer Red Crag, only the Coralline Crag crops up.

At a later date the newer Crag-sea waters appear to have worn a channel between the Coralline cliff on one side, and the Ramsholt old Crag before referred to. In the latter instance the presence of the seam of coprolites at the base of the old cliff is easily accounted for; their weight would necessarily cause them to gravitate downwards.

Having raised these points, they are left for the consideration of those interested in the subject.

The newer Red Crag, or that which we termed the Upper Crag, embraces, as we think, the newer Red Crag just referred to, the Scrobicularian Crag at Chillesford and Tunstall, the Fluvio-marine Crag at Thorpe, Bulchamp, and Wangford in Suffolk, Thorpe and Bramerton in Norfolk.

In the distribution of the Fluvio-marine Crags, as also of that of the Chillesford Series, we follow Messrs. Wood and Harmer for various reasons, chiefly palæontological, with a slight reservation as to whether the Norfolk Thorpe, and Postwick beds are of the Chillesford or Fluvio-marine stage. A capital idea of the marine fauna of this horizon and its mode of occurrence can be gained by a visit to Butley Neutral Farm Pit, a short account of which may be found in the "Geological Magazine," vol. viii., p. 450, with a list of its fossils. At Butley Mill and Chillesford Stack-yard, it may also be well seen, and at Sudbourne Church Walks it is to be found below the Chillesford Sands. In this direction it rests upon a ridge of hard Coralline Crag (containing rare Crustacea and Echini, *Gonoplax angulatus* and *Echinus Lyellii*) to the north of which, at Thorpe, it loses its ferruginous colour, becoming white. In addition to the ordinary Fluvio-marine shells, Mr. Cavell, of Saxmundham, and myself, have obtained many of the species common at Butley, sufficient to establish the synchronism of the two deposits. Here many fragments of bones are in places mixed with the shells.

In a cutting by the side of the railroad leading to Aldborough, the members of the Geological Society of Norwich, in one of their excursions, traced the land and other shells of the Fluvio-marine Crag into a highly ferruginous deposit, *Helix hispida* amongst others.

North of this the stratification becomes exceedingly confused, the Crag either being denuded or covered with sands and clays of a later date. In the few places where it occurs the fauna is mostly alike, no very great changes taking place till the neighbourhood of Norwich is reached. Here, through the assiduous labours of the Norfolk geologists, our knowledge has been greatly enlarged, and the fauna much increased.

On the top of the Chalk cliffs, at Thorpe, occurs a layer of flints, locally known as the "Stone Bed." In this layer the bones and teeth of many mammals have been found, and, mixed with them, numerous shells, all of recent species. The Rev. John Gunn and others consider this Stone Bed to be anterior to the Crag, but, as in the case of the Red Crag mammals already spoken of, no sufficient evidence has been produced to make this a matter of certainty. The occurrence of bones at Thorpe in Suffolk, at Whitlingham, at Bramerton, and other places, militates against this conclusion.

In the Suffolk district the sudden appearance of *Scrobicularia* in profusion in the Red Crag demonstrates a rapid change of the conditions of sea-bottom. A similar circumstance obtains at Bramerton, a fortunate discovery made by Mr. Reeves, of the Norwich Museum.

The limits of this paper do not allow of our dwelling upon this part of the subject; it will be sufficient to say, as already said, that the marine fauna of the Norwich, or Fluvio-marine Crags, assimilates that deposit to the upper part, as we have defined it, of the Suffolk Red Crag, and not to that of the lower; and with regard to the terrestrial fauna, whilst the Mammalia are somewhat similar to those of the older beds, the Mollusca are different. It is true that only one shell is known in the older Crag, occurring at Walton and Waldringfield, but that is an extinct or unknown form, while the whole of the newer land shells, whether at Butley, Bulchamp, Bramerton, or elsewhere, are recent species, mostly, if not all, British.

At the close of this stage a general subsidence took place over the East Anglian area, allowing the deposition of sands of varying thickness and colour. This sand may be seen at Walton-Naze, but is better displayed further north about Butley and Chillesford, and at Wangford, Bulchamp, and Bramerton, filling up eroded sands and hollows. Itself almost unfossiliferous, it invariably comes in and underlies the Chillesford shell-bearing sands, to which series it has been assigned.

Whether this assignment is correct or not is a matter of little moment, but the shelly sands have not yet been traced further south than the Chillesford pit. Between this pit and that at Butley Neutral Farm the unfossiliferous sands are to be seen coming to the surface in a run down pit on the side of a hill. A section of the Farm Pit is elsewhere given ("Geol. Mag.," op. cit.).

The Chillesford Sands do not present many new forms—a *Scalaria*, *Lucinopsis*, and *Echinus*—all living in the British Seas, appear for the first time. This statement does not harmonise with that by Mr. Prestwich, who remarks "that at this time colder currents from the north introduced new and more Arctic species of Mollusca."

In the absence of lists of species of the shells discovered in the colder areas of the deep seas round Britain, the fauna, judged by the lists given at the end of this paper, will be found to agree more nearly with that of the Norwegian coast about Drontheim than of a higher Arctic temperature, the fauna of which may be correlated more closely with the antecedent Upper Crag, and this, with the vegetation of the Forest Bed, whose relations with the Chillesford Sands are not clearly made out at present, imply, I think, a warmer climate for these latter beds than for the earlier Upper Crag.

The Chillesford shelly sands have been found at Chillesford, Sudbourn Church, Easter, Aldeby, Bramerton,* and in the Bure Valley, and perhaps on the coast near Runton Gap. This last is doubtful, as we agree with Mr. Wood upon the whole in considering that the coast and other sands containing *Tellina Baltica* are of a later stage, the shell in question, together with its surroundings, marking a very different horizon.

But few mammals have been found in the Chillesford Sands, the *Mastodon* apparently reaching its terminal point at this stage. We say apparently, because traces of the Crag *Mastodon*, or else one of another species, have been met with higher up still in the Post Tertiary series of the East of England. Remains of Rodentia and Ruminantia have been met with, and also one or more species of Cetacea.

Superimposed upon these sands are clays, in which, at Chillesford brick pit, a whale 31 feet in length was found. In consequence of the uncertainty attending the correlation of this and similar clays elsewhere, it may be prudent to doubt whether they do not belong to a higher group, that of the Lower Boulder Clays (Wood and Harmer), and not to the Chillesford Series at all.

The Forest Bed, according to some authors, overlies, and according to others, underlies the Chillesford Clays, the reason of this being that authors are not agreed as to what the Chillesford Clay is.

The non-appearance of the Mastodon in the Forest Bed, and the abundance of remains not previously met with, seem to prove the superiority of the Forest Bed to the Chillesford Sands. May not the fact be that as the beds inosculate they were nearly co-existent, the submergence of the Forest Bed afterwards permitting the deposition of "the laminated clays" upon the late land surface.

The consideration of this, as of the distribution of the Fluvio-marine Crag in Norfolk, and the newer Chillesford Series, being beyond the scope of this paper, we now conclude, hoping to take up the latter subject at some future period.

No collected list of the Pliocene fossils of England has been published, and the following, compiled from the collections and lists of Messrs. Wood, Crowfoot, Dowson, Harmer, Norton, Fitch, Reeve,

* By Mr. J. E. Taylor, who first worked out the separation between the Upper and Lower shell-bearing sands at Bramerton, and elsewhere in Norfolk.

Canham, Reed, Gunn, Fisher, Prestwich, and our own and those of our brother, G. W. Bell (Polyzoa)—as well as of those in various museums and publications is, perhaps, the most perfect yet issued; and we hope it may be found as useful to others as it has been to ourselves.*

CATALOGUE OF SPECIES IN THE ENGLISH CRAGS.

LOWER CRAG.

(CORALLINE CRAG.)

MAMMALIA.

Cervus, dicranoceros, *Kaup.*
„ sp.
Mastodon arvernensis, *Croizet.*
„ Borsoni.
Rhinoceros Schleirmacheri, *Kaup.*
Balæna emarginata, *Owen.*
„ gibbosa, *Owen.*
Phocœna, sp.
Ziphius, sp.

AVES.

Leg bone of a Wader.

PISCES.

Carcharodon megalodon, *Ag.*
Lamna, sp.
Merlangus virens, *Flem.*
„ pollachius, *Flem.*
„ vulgaris, *Flem.*
Morrhua vulgaris, *Cuv.*
„ lusca, *L.*
„ minutus, *L.*
„ aglæfinus, *L.*
Oxyrhina xiphodon, *Ag.*
Platax Woodwardii, *Ag.*
Raia antiqua, *Ag.*
Zygobatis Woodwardii, *Ag.*

CRUSTACEA.

Atelecyclus heterodon, *Leach.*
Cancer pagurus, *L.*
„ mænas, *L.*
Ebalia Bryerii, *Leach.*
Gonoplax angulata, *Leach.*
Maia squinado, *Leach.*
Pagurus Bernhardus, *L.*
Portunus puber, *L.*
„ depurator.

ENTOMOSTRACA.

Bairdia subdeltoidea, *Munst.*
Cythere botellina, *Jones.*
„ ceratoptera, *Bosq.*
„ dictyosigma, *Jones.*
„ sublacunosa, *Jones.*
* „ laqueata, *Jones.*
Cythere macropora, *Bosq.*
„ punctata, *Munst.*
„ retifastigiata, *Jones.*
„ sphærulolineata, *Jones.*
* „ trachypora, *Jones.*
„ trigonula, *Jones.*
„ Woodiana, *Jones.*
„ senilis, *Jones.*
Cytheridea pinguis, *Jones.*
Cytherideis Ren, *Jones.*
* „ tuberculata, *Jones.*
Loxoconcha tamarindus, *Jones.*

CIRRIPEDIA.

Acasta undulata, *Darw.*
Balanus bisulcatus, *Darw.*
„ concavus, *Bronn.*
„ crenatus, *Brug.*
„ calceolus, *Ellis.*
„ inclusus, *Darw.*
„ spongicula, *Brown.*
Pyrgoma anglica, *Sow.*
Scalpellum magnum, *Wood.*
Verruca stromia, *Müll.*

ANNELIDA.

Ditrupa gadus, *Mont.*
„ subulata, *Berk.*
Cyclogyra multiplex, *Wood.*
Spirorbis heterostrophus, *Mont.*
„ carinatus, *Mont.*
„ granulatus, *Mont.*
„ nautiloides, *Lam.* (?)
„ sinistrorsus, *Mont.*
„ supraplana, *Wood.*
Vermilia vermicularis, *L.*
„ triquetra, *L.*
„ tricuspidata, *Sow.*

ECHINODERMATA.

Amphidetus cordatus, *Penn.*
Brissus Scillæ, *Ag.*
Comatula Brownii, *E. Forb.*
„ Ransomii, *E. Forb.*
„ Woodwardii, *E. Forb.*
Echinocyamus hispidulus, *E. Forb.*
„ oviformis, *E. Forb.*
Echinus Charlesworthii, *E. Forb.*
„ Woodwardi, *Desor.*

* I have to express my thanks for the courtesy shown me by so many geological friends, without whose aid the lists would not have extended to their present *length.*—ALFRED BELL.

Echinus Lyellii, *E. Forb.*
,, melo, *Lam.*
,, sphæra, *Müll.*
Spatangus purpureus, *Müll.*
,, regina, *E. Forb.*
Temnechinus excavatus, *Wood.*
,, melocactus, *E. Forb.*
,, globosus, *E. Forb.*

GASTEROPODA.

Aclis ascaris, *Turt.*
,, Gulsonæ, *Clark.*
,, supranitida, *Wood.*
,, unica, *Wood* non *Mont.*
,, Walleri, *Jeffr.*
Adeorbis subcarinatus, *Mont.*
,, supranitidus, *Wood.*
,, tricarinatus, *Wood.*
,, pulchralis, *Wood.*
Admete Reedi, *A. Bell.*
,, viridula, *Fabr.*
Aporrhais pespelicani, *L.*
Brocchia sinuosa, *Broc.*
Buccinopsis Dalei, *Sow.*
,, pseudo-Dalei, *Wood.*
Buccinum undatum, *L.*
Cæcum mammilatum, *Wood.*
,, trachæum, *Wood.*
,, glabrum, *Mont.*
Calyptrea Chinensis, *L.*
Cancellaria Bonelli, *Bellardi.*
,, contorta, *Bast.*
,, mitræformis, *Broc.*
,, subangulosa, *Wood.*
,, varicosa, *Broc.*
Capulus Hungaricus, *L.*
,, unguis, *Sow.*
Cassidaria bicatenata, *Sow.*
Cerithium granosum, *Wood.*
,, tricinctum, *Broc.*
,, trilineatum, *Phil.*
,, perpulchrum, *Wood.*
,, cribrarium, *Wood.*
,, varicula, *Wood.*
Cerithiopsis metaxa, *Della. Ch.*
,, tuberculare, *Mont.*
Chemnitzia costaria, *Wood.*
,, densecostata, *Phil.*
,, lactea, *L.*
,, internodula, *Wood.*
,, rufa, *Phil.*
,, costellata, *Wood.*
,, filosa, *Wood.*
,, indistincta, *Mont.*
,, rufescens, *E. Forb.*
,, suturalis, *Phil.* = O. pupa, *Crag Moll.*
Chiton fasicularis, *L.*
,, Rissoi, *Payr.*
,, Hanleyi, *Bean.*
Columbella sulcata, *Sow.*
Conopleura crassa, *A. Bell.*
Cyclostrema sphæroidea, *Wood.*
Cyprea Europea, *Mont.*
,, avellana, *Sow.*
,, retusa, *Sow.*
,, affinis, *Duj.*

Defrancia histrix, *Jan.*
,, linearis, *Mont.*
,, reticulata, *Ren.*
,, purpurea, *Mont.*
,, Philberti, *Mich.*
,, teres, *Forbes.* = Trophon paululum, *Wood.*
Emarginula crassa, *Sow.*
,, fissura, *L.*
,, rosea, *Bell.*
,, elongata, *Phil.*
Erato lævis, *Don.*
,, Maugeriæ, *Gray.*
Eulima subulata, *Mont.*
,, glabella, *Wood.*
,, polita. *L.*
Eulimella nitidissima, *Wood.*
Fissurella græca, *L.*
,, costaria, *Bast.*
Fossarus costatus, *Broc.*
,, = Phasianema sulcata, *Wood.*
,, Japonicus, *Adams.*
,, reticulata, *Wood.*
Fusus alveolatus, *Sow.*
,, consociale, *Wood.*
,, costifer, *Wood.*
,, gracilis, *Da Costa.*
,, gracilius, *Wood.*
,, imperspicuum, *Wood.*
Lamellaria perspicua, *L.*
Lepeta cæca, *Müll.*
Lacuna, sp.
Litiopa papillosa, *Wood.*
Margarita glauca, *Möll.*
,, maculata, *Wood.*
,, trochoidea, *Wood.*
Menestho Brittanica, *A. Bell.*
Mitra ebenus, *Lam.*
,, plicifera, *Wood.*
Murex aciculatus, *Lam.*
Nassa consociata, *Wood.*
,, granulata, *Sow.*
,, incrassata, *Strom.*
,, labiosa, *Sow.*
,, prismatica, *Broc.*
,, pygmæa, *Lam.*
,, granifera, *Duj.*
,, pulchella, *A. Bell.*
,, densecostata, *A. Bell.*
Natica catenoides, *Sow.*
,, cirriformis, *Wood.*
,, proxima, *Wood.*
,, millepunctata, *Lam.*
,, helicina, *Broc.* = N. varians, *Crag Moll.*
Odostomia acuta, *Jeffr.*
,, conoidea, *Broc.*
,, filosa, *Wood.*
,, plicata, *Mont.*
,, simillima, *Wood.*
,, decussata, *Mont.*
,, insculpta, *Mont.*
,, obliqua, *Alder.*
,, similis, *Wood.*
Ovula spelta, *L.*
Piliscus commodus, Midd.

Pleurotoma brachystoma, *Wood.*
,, carinata, *Biv.*
,, costata, *Don.*
,, curtistoma, *A. Bell.*
,, castanea, *Wood.*
,, concinnata, *Wood.*
,, decussata, *Phil.*
,, exilis, *A. Bell.*
,, elegans, *Moll.* ≡ Clavatula plicifera, *Wood.*
,, elegantula, *A. Bell.*
,, galerita, *Phil.* = P. semicolon, *Crag Moll.*
,, gracilior, *A. Bell.*
,, mitrula, *Sow.*
,, nebula, *Mont.*
,, porrecta, *S. Wood.*
,, notata, *A. Bell.*
,, perpulchra, *Wood.*
,, pannum, *Bast.*
,, striolata, *Scac.*
,, Tarentini, *Phil.*
,, tenuistriata, *A. Bell.* = E. lævigata, *Wood.*
,, volvula, *A. Bell.*
Puncturella Noachina, *L.*
Pyramidella plicosa, *Bronn.* = P. læviuscula, *Wood.*
Pyrula cancellata, *Grat.*
Ringicula auriculata, *Men.*
,, ventricosa, *Sow.*
Rissoa calathus, *F.* and *H.*
,, concinna, *Wood.*
,, confinis, *Wood.*
,, crassistriata, *Wood.*
,, curticostata, *Wood.* = R. semicostata, *Crag Moll.*
,, inconspicua, *Ald.*
,, obsoleta, *Wood.*
,, proxima, *Alder.*
,, soluta, *Phil.*
,, Stefanisi, *Jeff.*
,, striata, *Mont.*
,, supracostata, *Wood.*
,, vitrea, *Mont.* (?)
,, Zetlandica, *Mont.*
Scalaria clathratula, *Ad.*
,, cancellata, *Broc.*
,, fimbriosa, *Wood.*
,, foliacea, *Sow.*
,, frondosa, *Sow.*
,, frondicula, *Wood.*
,, hamulifera, *Wood.*
,, subulata, *Nyst.*
,, varicosa, *Lam.*
,, obtusicostata, *Wood.*
Scissurella crispata, *Flem.*
Sigaretus excavatus, *Wood.*
Terebra inversa, *Nyst.*
,, canalis, *Wood.*
,, exilis, *A. Bell.*
Trichotropis borealis, *Sow.*
Triton heptagonum, *Wood* non *Brocchi.*
Trochus Adansonii, *Payr.*
Trochus Kickxii, *Nyst.*
,, millegranus, *Wood* non *Phil.*
,, multigranus, *Wood.*
,, Montacuti, *W. Wood.*
,, occidentalis, *Migh.*
,, villicus, *Phil.*
,, ziziphinus, *L.*
,, conulus, *L.*
,, ditropis, *Wood.*
,, Duminyi, *Req.* = Adeorbis striatus, *Wood.*
,, obconicus, *Wood.*
,, tricariniferus, *Wood.*
,, bullatus, *Phil.*
Trophon muricatum, *Mont.*
Triforis adversum, *Mont.*
,, perversum, *L.*
Turritella incrassata, *Sow.*
,, planispira, *Wood.*
Velutina undata, *Smith.* = V. virgata, *Wood.*
Vermetus subcancellatus, *Biv.* = V. intortus, *Crag Moll.*
Voluta Lamberti, *Sow.*

SOLENOCONCHA.

Dentalium dentalis, *L.*
Dischides Olivi *Scac.*

OPISTHOBRANCHIATA.

Actæon tornatilis, *L.*
,, levidensis, *Wood.*
Bulla utriculus, *Broc.*
Cylichna cylindracea, *Penn.*
,, concinna, *Wood.*
,, conuloidea, *Wood.*
Philine catena, *Mont.*
,, quadrata, *Wood.*
,, scabra, *Müll.*
,, ventrosa, *Wood.*
Scaphander lignarius, *L.*
,, librarius, *Loven.*
Utriculus nana, *Wood.*
,, Lajonkairii, *Bast.*
,, obtusus, *Mont.*
,, truncatulus, *Brug.*
Volvula acuminata, *Brug.*

PTEROPODA.

Cleodora infundibulata, *Wood.*

LAMELLIBRANCHIATA.

Anomia ephippium, *L.*
,, striata, *Broc.*
,, patelliformis, *L.*
Arca lactea, *L.*
,, tetragona, *Poli.*
,, nodulosa, (?)*
,, pectunculoides, *Scac.*
Artemis exoleta, *L.*
,, lincta, *Pult.*
Astarte Basterotii, *La Jonk.*
,, Burtini, *La Jonk.*
,, Galeottii, *Nyst.* = A. gracilis, *Wood* non *Münst.*

* Will be shortly figured together with some other species, now recorded for the *first time* as Crag species.—A. B.

Astarte incrassata, *Broc.*
„ mutabilis, *Wood.*
„ Omalii, *La Jonk.*
„ triangularis, *Mont.*
„ incerta, *Wood.*
„ parvula, *Wood.*
„ pusilla, *E. Forb.* = A. parva, *Wood.*
„ pygmæa, *Münst.*
Avicula hirundo, *L.*
Axinus flexuosus, *Mont.*
„ ferruginosus, *E. Forb.*
Cardita corbis, *Phil.*
„ chamæformis, *Leathes.*
„ scalaris, *Leathes.*
„ sulcata, *Brug.* = C. senilis, *Lam.* (part).
„ rudista, *Lam.* = C. senilis (part).
„ orbicularis, *Leathes.*
Cardium decorticatum, *Wood.* (C. lævigatum, *Poli.*)
„ edule, *L.*
„ fasciatum, *Mont.*
„ interruptum, *Wood.*
„ elegantulum, *Möll.*
„ Norvegicum, *Spengl.*
Chama gryphoides, *L.*
Circe minima, *Mont.*
Cochlodesma prætenue, *Pult.*
Corbula gibba, *Olivi.*
Crenella rhombea, *Berk.*
Cultellus tenuis, *Phil.*
Cyamium eximium, *Wood.*
Cypricardia lithophagella, *Wood.*
Cyprina Islandica, *L.*
„ rustica, *Sow.*
Cytherea chione, *L.*
„ rudis, *Poli.*
Diplodonta astartea, *Nyst.*
„ dilatata, *Wood.*
„ rotundata, *Mont.*
Donax trunculus, *L.*
„ vittatus, *Da Costa.*
„ politus, *Poli.*
Erycina Geoffroyi, *Payr.*
Erycinella ovalis, *Conrad.*
Galeomma compressa, *Phil.* = Kellia coarctata, *Wood.*
Gastrana laminosa, *Sow.*
Gastrochæna dubia, *Penn.*
Glycimeris angusta, *Nyst.*
Hinnites giganteus, *Carpenter.*
Isocardia cor, *L.*
Kellia ambigua, *Nyst.*
„ suborbicularis, *Mont.*
„ cycladia, *Wood.*
„ elliptica, *Wood.*
„ pumila, *Wood.*
Lasea rubra, *Mont.*
Leda pygmea, *Münst.*
„ semistriata, *Wood.*
Lepton nitidum, *Turt.* = L. depressum, *Crag Moll.*
„ squamosum, *Mont.*
„ Clarkæ, *Clark.*
Lima elliptica, *Jeffr.*
„ hians, *Gmel.*
„ nivea, *Ren.*
„ Loscombii, *Sow.*
„ inflata, *Chemn.*
„ subauriculata, *Mont.*
„ squamosa, *Lam.* = L. plicatula, *Wood.*
Limopsis aurita, *Lam.*
„ pygmea, *Phil.*
Lucina borealis, *L.*
„ crenulata, *Conr.*
„ decorata, *Wood.*
Lucinopsis Lajonkairii, *Payr.*
Lutraria elliptica, *Lam.*
„ oblonga, *Chemn.*
Mactra arcuata, *Sow.*
„ stultorum, *L.*
„ elliptica, *Brown.*
„ subtruncata, *Da. Costa.*
„ artopta, *Wood.*
Modiolaria costulata, *Risso.*
„ discors, *L.*
„ marmorata, *E. Forb.*
„ sericea, *Bronn.*
Montacuta bidentata, *Mont.*
„ ferruginosa, *Mont.*
„ substriata, *Mont.*
„ donacina, *Wood.*
„ truncata, *Wood.*
„ ovata, *Jeffr.*
Mya truncata, *L.*
Mytilus phaseolinus, *Phil.*
„ ungulatus, *L.*
„ modiolus, *L.*
Næara arctica, *Sars.*
„ cuspidata, *Olivi.*
„ jugosa, *Wood.*
Nucinella miliaris, *Desh.*
Nucula lævigata, *J. Sow.*
„ nucleus, *L.*
„ tenuis, *Mont.*
„ trigonula, *Wood.*
Ostrea cochlear, *Poli.*
„ cristata, *Born.*
„ edulis, *L.*
„ princeps, *Wood.*
Pandora obtusa, *Leach.*
Panopea fragilis, *Nyst.*
„ Faujasii, *Menard.*
Pecten dubius, *Broc.*
„ maximus, *L.*
„ opercularis, *L.*
„ princeps, *Wood.*
„ pusio, *L.*
„ tigrinus, *Müll.*
„ aratus, *Gmel.*
„ Gerardii, *Nyst.*
„ similis, *Laskey.*
Pectunculus glycimeris, *L.*
„ insubricus, *Broc.*
Pholadidea papyracea, *Sol.*
Pholadomya hesterna, *Sow.*
Pholas crispata, *L.*
„ cylindrica, *Sow.*
Pinna rudis, *L.*

Poromya granulata, *Nyst.*
Psammobia costulata, *Turt.*
„ Ferröensis, *Chemn.*
„ tellinella, *Lam.*
„ vespertina, *Chemn.*
Saxicava arctica, *L.*
Solecurtus strigillatus.
Solen ensis, *L.*
„ pellucidus, *Penn.*
Sphænia Binghami, *Turt.*
Syndosmya alba, *W. Wood.*
„ prismatica, *Mont.*
Tapes Virginea, *L.*
„ *var.* Sarniensis, *Turton.* = T. perovalis, *Wood.*
Tellina crassa, *Penn.*
„ donacina, *L.*
„ obliqua, *Sow.*
„ balaustina, *L.*
„ compressa, *Broc.* = T. donacilla, *Wood.*
Teredo Norvegica, *Spengl.*
Thracia convexa, *W. Wood* (*Prestwich*).
„ inflata, *Sow.*
„ papyracea, *Poli.*
„ distorta, *Mont.*
„ pubescens, *Pult.*
„ ventricosa, *Phil.*
Venus casina, *L.*
„ fasciata, *Don.*
„ imbricata, *Sow.*
„ ovata, *Penn.*
„ dysera, *Broc.*
Verticordia cardiiformis, *Wood.*
Woodia digitaria, *Gmel.*
„ excurrens, *Wood.*

BRACHIOPODA.

Argiope cistellula, *S. Wood.*
Crania Atlantica, *King.*
Lingula Dumortieri, *Nyst.*
Terebratula grandis, *Blum.*
„ caput serpentis, *Flem.*

POLYZOA.

Alecto dilatans, *Thomp.*
„ repens, *Wood.*
Alveolaria semiovata, *Busk.*
Alysidota catena, *Wood.*
Biflustra delicatula, *Busk.*
Cellepora cespitosa, *Busk.*
„ compressa, *Busk.*
„ coronopus, *Wood.*
„ dentata, *Busk.*
„ edax, *Busk.*
„ parasitica, *Michel.*
„ ramulosa, *L.*
„ tubigera, *Busk.*
„ scruposa.
Crisia denticulata, *Lam.*
Cupularia canariensis, *Busk.*
„ denticulata, *Conr.*
„ porosa, *Busk.*
Defrancia rugosa, *Busk.*
Defrancia striatula, *Busk.*
Diastopora simplex, *Busk.*
Discoporella Grignonensis, *M. Edw.*
„ hispida, *Johnst.*
Eschara cornuta, *Busk.*
„ incisa, *M. Edw.*
„ monilifera, *M. Edw.*
„ pertusa, *M. Edw.*
„ porosa, *M. Edw.*
„ Sedgwickii, *M. Edw.*
„ sinuosa, *Busk.*
„ socialis, *Busk.*
Fascicularia aurantia, *Busk.*
„ tubipora, *Busk.*
Flustra dubia, *Busk.*
Fungella infundibulata, *Busk.*
„ multifida, *Busk.*
„ quadriceps, *Busk.*
Hemeschara imbellis, *Busk.*
Heteropora clavata, *Goldf.*
„ lævigata, *D'Orb.*
„ pustulosa, *Busk.*
„ reticulata, *Busk.*
Heteroporella parasitica, *Busk.*
„ radiata, *Busk.*
Hippothoa abstersa, *Wood.*
„ dentata, *Wood.*
„ patagonica, *Busk.*
Hornera canaliculata, *Busk.*
„ frondiculata, *Lamx.*
„ hippolyta, *Defr.*
„ humilis, *Busk.*
„ infundibulata, *Busk.*
„ lunata, *Busk.*
„ pertusa, *Busk.*
„ reteporacea, *M. Edw.*
„ rhipis, *Busk.*
„ rhomboidalis, *Busk.*
„ striata, *M. Edw.*
Idmonea delicatula, *Busk.*
„ fenestrata, *Busk.*
„ intricaria, *Busk.*
„ punctata, *D'Orb.*
Lepralia annulata (*Prestwich.*)
„ ansata, *Johnst.*
„ biaperta, *Michel.*
„ bicornis, *Busk.*
„ Bowerbankiana, *Busk.*
„ Brongniartii, *Aud.*
„ ciliata, *L.*
„ Haimesiana, *Busk.*
„ hyalina, *L.*
„ innominata, *Couch.*
„ lobata, *Busk.*
„ Malusii, *Aud.*
„ mammillata, *Wood.*
„ Milneana, *Busk.*
„ megastoma, *Wood.*
„ Morrisiana ? (*Prestwich*)
„ Pallasiana, *Möll.*
„ papillata, *Busk.*
„ Peachii, *Johnst.*
„ plagiopora, *Busk.*
„ punctata, *Hass.*
„ puncturata, *Wood.*
„ pyriformis, *Wood.*

Lepralia Reussiana, *Busk.*
,, variolosa, *Johnst.*
,, ventricosa, *Hass.*
,, violacea, *Johnst.*
,, unicornis, *Johnst.*
,, Woodiana, *Busk.*
Lunulites conica, *Defr.*
Membranipora aperta, *Busk.*
,, Andegavensis, *Michel.*
,, bidens, *Hagen.*
,, dubia, *Busk.*
,, fissurata, *Busk.*
,, holostoma, *Wood.*
,, Lacroixii (*Prestwich.*)
,, monostachys, *Busk.*
,, oblonga, *Busk.*
,, Oceanii, *D'Orb.*
,, Pouilletti, *And.*
,, rhynchota, *Busk.*
,, Savartii, *Aud.*
,, trifolia, *Wood.*
,, tuberculata, *Bosc.*
Melicerita Charlesworthi, *M. Edw.*
Mesenteripora meandrina, *Wood.*
Patinella proligera, *Busk.*
Pustulopora clavata, *Busk.*
,, palmata, *Busk.*
,, subverticellata, *Busk.*
Retepora Beaniana, *King.*
,, cellulosa, *L.*
,, notopachys, *Busk.*
,, simplex, *Busk.*
Salicornaria crassa, *Wood.*
,, sinuosa, *Hassall.*
Scrupocellaria scruposa, *L.*
Tubulipora flabellaris, *Fabr.*
,, phalangea, *Couch.*

CŒLENTERATA.

Cryptangia Woodii, *E. & H.*
Flabellum Woodii, *E. & H.*
Sphenotrochus intermedius, *Münst.*

SPONGIDA.

Alcyonium circumvestiens, *Wood.*

FORAMINIFERA.

Alveolina.
Amphistegina vulgaris, *D'Orb.*
Biloculina elongata, *D'Orb.*
,, ringens, *Lam.*
,, depressa, *D'Orb.*
Bolivina punctuata, *D'Orb.*
Bulimina marginata, *D'Orb.*
Calcarina rarispina, *D'Orb.*
Cassidulina crassa, *D'Orb.*
,, lævigata, *D'Orb.*
,, oblonga, *Reuss.*
Cornuspira foliacea, *Phil.*
,, involvens, *Reuss.*
Cristellaria cultrata, *Mont.*
Dendritina arbuscula, *D'Orb.*
Dentalina communis, *D'Orb.*
Dentalina obliqua, *Lam.*
,, obliquestriata, *Reuss.*
,, pauperata, *D'Orb.*
Dimorphina nodosaria, *Reuss.*
,, tuberosa, *D'Orb.*
Discorbina Parisiensis, *D'Orb.*
,, rosacea, *D'Orb.*
Glandulina lævigata, *D'Orb.*
Globigerina bullöides, *D'Orb.*
Lagena sulcata, *Walker.*
,, apiculata, *Reuss.*
,, globosa, *Mont.*
,, gracillima, *Seg.*
,, lævis, *Mont.*
,, marginata, *Mont.*
,, melo, *D'Orb.*
,, ornata, *Will.*
,, semistriata, *D'Orb.*
,, striata, *D'Orb.*
Marginulina glabra, *D'Orb.*
,, raphanus, *D'Orb.*
Nodosaria raphanus, *L.*
,, raphanistrum, *L.*
,, scalaris, *Batsch.*
Nonionia faba, *F. & M.*
,, scapha, *F. & M.*
Nummulina planulata, *Lam.*
Operculina complanata, *Defr.*
Orbiculina adunca, *F. & M.*
,, compressa, *D'Orb.*
Orbitoides Faujasii, *Defr.*
Orbitolites orbiculus, *Försk.*
,, complanata, *Carp.*
Ovulites elongata, *Lam.*
Planorbulina Haidingeri, *D'Orb.*
,, Mediterranensis, *D'Orb.*
,, Ungeriana, *D'Orb.*
Polymorphina compressa, *D'Orb.*
,, complanata, *D'Orb.*
,, frondiformis, *Wood.*
,, gibba, *D'Orb.*
,, gutta, *D'Orb.*
,, lactea, *W. & J.*
,, problema, *D'Orb.*
,, rugosa, *D'Orb.*
,, Thouinii, *D'Orb.*
,, tubulosa, *D'Orb.*
,, variata, *Jones.*
Polystomella crispa, *L.*
,, macella, *F. & M.*
,, striato-punctata, *F. & M.*
Pullenia sphæroides, *D'Orb.*
Pulvulina auricula, *F. & M.*
,, elegans, *D'Orb.*
,, pulchella, *D'Orb.*
,, repanda, *F. & M.*
Quinqueloculina seminulum, *L.*
,, Brongniartii, *D'Orb.*
,, Ferussacci, *D'Orb*
,, pulchella, *D'Orb.*
,, subrotunda, *Mont.*
,, tenuis, *Czjcek.*
,, triangularis, *D'Orb.*
Rotalia Beccarii, *L.*
,, orbicularis, *D'Orb.*
Spirillina vivipara, *Ehr.*

Spirolina cylindracea, *Lam.*
Spiroloculina canaliculata, *D'Orb.*
„ planulata, *Lam.*
Textularia saggitula, *Defr.*
„ agglutinans, *D'Orb.*
„ gibbosa, *D'Orb.*
„ trochus, *D'Orb.*
Tinoporus lævis, *P. & J.*
Triloculina oblonga, *Mont.*
Triloculina tricarinata, *D'Orb.*
Truncatulina lobatula, *W. & J.*
Verneuilina communis, *D'Orb.*
Vaginulina linearis, *Mont.*
Webbina hemisphærica, *Jones.*

PLANTÆ.

Gorgonia, sp.
Nullipora, sp.

MIDDLE CRAG.
(OLDEST RED CRAG).

* Species so distinguished pass into the Upper Crag.

MAMMALIA.||

TERRESTRIAL.
Canis primigenius, *Lank.*
Castor veterior, *Lank.*
Cervus dicranoceros, *Kaup.*
„ megaceros (?) *Harte.*
Elephas meridionalis, *Nesti.* ?
„ antiquus, *Falconer.*
Equus plicidens, *Owen.*
Felis pardoides, *Owen.*
Hipparion.
Hippotherium gracile, *Kaup.*
*Hyæna antiqua, *Lank.*
Mastodon arvernensis, *Croizet.*
„ Borsoni.
Pterodon.
Sus antiquus, *Kaup.*
„ palæochærus, *Kaup.*
„ arvernensis, *Kaup.*
Tapirus priscus, *Kaup.*
Rhinoceros Schleirmacheri, *Kaup.*
Ursus.
Vespertilio, sp.

MARINE.
Balæna affinis, *Owen.*
„ definita, *Owen.*
„ emarginata, *Owen.*
„ gibbosa, *Owen.*
Balænodon physaloides.
Balænoptera boops, *Owen.*
Choneziphius planirostris, *Cuv.*
„ Packardi, *Lank.*
Delphinus, sp.
Hoplocetis crassidens, *Gerv.*
Phocœna orcoides, *Lank.*
„ uncidens, *Lank.*
„ orca (?)
Physeter macrocephalus.
Squalodon Antwerpiense, *Van Ben.*
Trichecodon Huxleyi, *Lank.*
Ziphius angustus, *Owen.*
„ compressus, *Huxl.*
„ angulatus, *Owen.*
„ declivis, *Owen.*
„ gibbus, *Owen.*
„ planus, *Owen.*
„ undatus, *Owen.*
„ medilineatus, *Owen.*

PISCES.§

Anarhicas lupus, *L.*
Carcharodon megalodon, *Agr.*
*Platax Woodwardii, *id.*
*Raia antiqua, *Ag.*
* „ sp.
*Zygobatis Woodwardii, *Ag.*

CRUSTACEA.

*Cancer pagurus, *L.*
*Carcinas mænas, *L.*

ENTOMOSTRACA.
Bairdia subdeltoidea, *Münst.*
Cythere laqueata, *Jones.*
„ trachypora, *Jones.*
Cytherideis tuberculata, *Jones.*

CIRRIPEDIA.
Balanus concavus, *Bronn.*
* „ crenatus, *Brug.*
* „ dolosus, *Darw.*
* „ Hameri, *Asc.*
* „ porcatus, *Da Costa.*
* „ tintinnabulum, *L.*
„ inclusus, *Darw.*
Coronula barbata, *Darw.*
Verruca stromia, *Müll.*

ANNELIDA.

*Ditrupa gadus, *Mont.*
Serpula vermicularis, *L.*
„ triquetra, *Mont.*
Spirorbis carinatus, *Mont.*

ECHINODERMATA.

Echinarachinus Woodii.
Echinocyamus hispidulus, *E. Forb.*
„ oviformis, *E. Forb.*
* „ pusillus, *Müll.*
„ Suffolciensis, *Ag.*
Echinus Henslovii, *E. Forb.*
„ Nortoni, *A. Bell.* (n. sp.)
„ Woodwardi, *Desor.*
*Spatangus purpureus, *Müll.*
Temnechinus turbinatus, *E. Forb.*
„ excavatus, *Wood.*
Uraster rubens, *Retz.*
„ sp.

|| The names adopted are those given by Prof. Owen, and are chiefly those of Miocene species. Dr. Falconer, on the other hand, considers they may be assigned to Pliocene forms.

§ Teeth of Lamna, Oxyrhina, Otodus, &c., also occur. Age uncertain.

GASTEROPODA.

Adeorbis subcarinata, *Mont.*
*Admete viridula, *Fabr.*
„ Couthouyii, *Say.*
*Aporrhais pespelicani, *L.*
Brocchia partim-sinuosa, *Wood.*
„ incerta, *A. Bell.*
*Buccinopsis Dalei, *Sow.*
Buccinum glaciale, *Chemn.*
* „ undatum, *L.*
Cæcum mamillatum, *Wood.*
*Calyptrea Chinense, *L.*
Cancellaria avara, *Say.*
* „ scalaroides, *Wood.*
„ varicosa, *Broc.*
„ mitræformis, *Broc.*
*Capulus hungaricus, *L.*
* „ militaris, *Wood*, non *Mont.*
* „ unguis, *Sow.*
*Cassidaria bicatenata, *Sow.*
(var.) Canhami, *A. Bell.*
Cerithiopsis metaxa, *Della Ch.*
*Cerithium granosum, *Wood.*
„ perpulchrum, *Wood.*
„ reticulatum, *Da. Costa.*
* „ tricinctum, *Broc.*
„ trilineatum, *Phil.*
„ variculosum, *Nyst.*
Chemnitzia costaria, *Wood.*
„ densecostata, *Phil.*
„ lactea, *L.*
* „ internodula, *Wood.*
„ suturalis, *Phil.*
* „ plicatula, *Broc.*
*Columbella sulcata, *Sow.*
* „ abbreviata, *A. Bell.*
* „ Borsoni, *Bell.*
Conopleura Maravignæ, *Biv. (Jeffreys).*
*Cypræa avellana, *Sow.*
„ Dertonensis, *Michel.*
* „ Europea, *Mont.*
* „ retusa, *Sow.*
Defrancia cancellata, *Sow.*
* „ linearis, *Mont.*
„ histrix, *Jan.*
„ Leufroyi, *Mich.* = Clav. Boothii, *Crag Moll.*
„ Philberti, *Mich.*
„ reticulata, *Ren.*
Desmoulea conglobata, *Broc.*
Emarginula crassa, *Sow.*
* „ fissura, *L.*
*Erato lævis, *Don.*
* „ Maugeriæ, *Gray.*
Eulima distorta, *Desh.*
„ glabella, *Wood.*
* „ polita, *L.*
„ subulata, *Wood.*
Eulimella acicula, *Phil.*
*Fissurella græca, *L.*
„ costaria, *Bast.*
*Fusus altus, *Wood.*
„ alveolatum, *Sow.*
„ Americanus, *A. Bell.*
* „ antiquus, *L.*
*Fusus contrarius, *L.*
„ cordatus, *A. Bell.*
„ consociale, *Wood.*
* „ costifer, *Sow.*
„ crispus, *Borson.* (?)
* „ despectus, *L.*
„ elegans, *Charlesw.*
* „ gracilis, *Da. Costa.*
„ Islandicus, *Chemn.*
„ Norvegicus, *Chemn.*
* „ Sarsii, *Jeffr.*
„ Jeffreysius, *Fischer.*
*Hydrobia ulva, *Penn.*
Lachesis, n. sp.
Lacuna crassior, *Mont.*
*Littorina suboperta, *Wood.*
* „ littorea, *L.*
*Lepeta cæca, *Müll.*
Melampus myosotis, *Drap.*
„ pyramidalis, *Sow.*
Menestho Jeffreysii, *A. Bell.*
Mitra ebenus, *Lam.*
„ fusiformis, *Broc.*
*Murex tortuosus, *Sow.*
„ insculpta, *Duj.*
*Nassa ascanias, *Brug.*
„ consociata, *Wood.*
„ elegans, *Leathes.*
* „ granulata, *Sow.*
* „ labiosa, *Sow.*
* „ monensis, *E. Forb.*
„ musiva, *Broc.* (?)
„ prismatica, *Broc.*
„ propinqua, *Sow.*
„ reticosa, *Sow.*
„ pulchella, *A. Bell.*
*Natica affinis, *Gmel.*
* „ catena, *Da Costa.*
* „ catenoides, *Wood.*
„ cirriformis, *Wood.*
„ duplicata, *Say.*
„ Guillelmini, *Wood*, non *Payr.*
* „ Islandica, *Gmel.*
„ hemiclausa, *Sow.*
* „ millepunctata, *Lam.*
* „ var. tigrina, *Phil.*
„ helicina, *Broc.*
„ herculea, *Midd.*
„ proxima (?) *Wood.*
„ sordida, *Phil.*
Odostomia acuta, *Jeffr.*
„ conoidea, *Broc.*
„ plicata, *Mont.*
„ unidentata, *Mont.*
*Ovula spelta, *L.*
*Paludestrina pendula, *Wood.*
„ terebellata, *Nyst.*
* (?) Patella vulgata, *L.*
Piliscus commodus, *Midd.*
*Pleurotoma Bertrandi, *Payr.*
„ carinata, *Biv.*
* „ contigua, *Broc.*
* „ costata, *Don.*
„ decussata, *Phil.*
„ elegans, *Möll.*
„ intorta, *Broc.*

Pleurotoma gracile ? *Phil.*
„ galerita, *Phil.*
„ harpularia, *Couthouy.*
„ lævigata, *Phil.*
* „ mitrula, *Wood.*
„ nebula, *Mont.*
„ oblonga, *Ren.* (?)
„ perpulchra, *Wood.*
* „ pyramidalis, *Strom.*
* „ rufa, *Mont.*
„ septangularis, *Mont.*
„ Trevellyana, *Turt.*
* „ turricula, *Mont.*
„ tenuistriata, *A. Bell.*
„ Arctica, *Adams.*
*Purpura lapillus, *L.*
* „ tetragona, *Wood.*
Pyramidella plicosa, *Duj.*
Pyrula acclinis, *Wood.*
„ cancellata, *Grat.*
Ranella anglica, *A. Bell.*
*Ringicula auriculata, *Men.*
* „ ventricosa, *Sow.*
*Rissoa curticosta, *Wood.*
* „ pulchella, *Wood*, non *Phil.*
„ Stefanisi, *Jeffr.*
„ Zetlandica, *Mont.*
*Scalaria clathratula, *Ad.*
„ communis, *Lam.*
„ fimbriosa, *Wood.*
„ foliacea, *Sow.*
* „ Greenlandica, *Chemn.*
„ subulata, *Nyst.*
„ varicosa, *Lam.*
„ pseudo-scalaris, *Broc.*
„ Trevelliana, *Leach.*
*Tectura virginea, *Müll.*
Terebra canalis, *Wood.*
* „ inversa, *Nyst.*
Trichotropis borealis, *B. & S.*
Triforis adversum, *Mont.*
*Trochus Adansoni, *Payr.*
„ bullatus, *Phil.*
* „ cinerarius, *L.*
* „ cineroides, *Sow.*
„ granosus, *Sow.*
* „ granulatus, *Born.*
„ Kickxii, *Nyst.*
„ millegranus, *Phil.*
* „ multigranus, *Wood.*
* „ Montacuti, *W. Wood.*
* „ occidentalis, *Mighels.*
* „ subexcavatus, *Wood.*
* „ tumidus, *Mont.*
* ? „ villicus, *Phil.*
* „ ziziphinus, *L.*
Trophon Barvicense, *Johnst.*
„ clathratus, *Mull.*
„ muricatum, *Mont.*
„ scalariforme, *Gould.*
*Turritella communis, *Risso.*
* „ incrassata, *Sow.*
„ subangulata, *Broc.*
*Vermetus subcancellatus, *Biv.*
„ glomeratus.
„ triqueter, *Biv.*
*Voluta Lamberti, *Sow.*

SOLENOCONCHA.

*Dentalium dentalis, *L.*
„ rectum, *Gmel.*
„ abyssorum, *Sars* (fide *Jeffreys*).

OPISTHOBRANCHIATA.

Actæon Noæ, *Sow.*
* „ tornatilis, *L.*
* „ subulata, *Wood.*
?Actæon Etheridgii, *A. Bell.*
*Cylichna cylindracea, *Penn.*
Scaphander lignarius.

LAMELLIBRANCHIATA.

Amphidesma deaurata, *Turton.* = Mactra deaurata, *Crag Moll.*
*Anomia ephippium, *L.*
* „ patelliformis, *L.*
„ striata, *Broc.*
*Arca lactea, *L.*
* „ tetragona, *Poli.*
*Artemis exoleta, *L.*
* (?) „ lincta, *Pult.*
*Astarte Basterotii, *La Jonk.*
* „ Burtini, *La Jonk.*
* „ compressa, *Mont.*
„ crebriliratra, *Wood.*
„ Galeotti, *Nyst.*
„ incrassata, *Broc.*
„ mutabilis, *Wood.*
* „ obliquata, *Sow.*
* „ Omalii, *La Jonk.*
*‡ „ sulcata, *Da. Costa.*
„ triangularis, *Mont.*
*Cardita chamæformis, *Leathes.*
* „ corbis, *Phil.*
„ orbicularis, *Leathes.*
* „ scalaris, *Leathes.*
* „ rudista, *Lam.* = C. senilis (part).
*Cardium angustatum, *Sow.*
* „ decorticatum, *Wood.*
* „ echinatum, *L.*
* „ edule, *L.*
* „ interruptum, *Wood.*
* „ nodosum, *Turt.* (?)
„ nosodulum, *Turt.*
* „ Parkinsoni, *Sow.*
* „ venustum, *Wood.*
Chama gryphoides, *Lam.*
Circe minima, *Mont.*
Cochlodesma complanata, *Wood.*
*Corbula gibba, *Olivi.*
*Corbulomya complanata, *Sow.*
Cultellus tenuis, *Phil.*
*Cyprina Islandica, *L.*
(*?) „ rustica, *Sow.*
Cytherea chione, *L.*
* „ rudis, *Poli.*
*Diplodonta astartea, *Nyst.*
„ dilatata, *Wood.*
„ rotundata, *Mont.*
(*?)Donax trunculus, *L.*
* „ vittatus, *Da Costa.*
„ politus, *Poli.*

Erycinella ovalis, *Conr.*
Erycina Geoffroyi, *Payr.*
„ ovata, *Phil.* = Abra obovalis, *Wood.*
*Gastrana laminosa, *Sow.*
Gastrochæna dubia, *Penn.*
Glycimeris angusta, *Nyst.*
*Hinnites gigantea, *Carp.*
Isocardia cor, *L.*
*Kellia ambigua, *Nyst.*
„ suborbicularis, *Mont.*
*Leda lanceolata, *Sow.*
„ minuta, *Müll.*
* „ myalis, *Couth.*
„ pygmea, *Munst.*
Lima inflata, *Chemn.*
„ Loscombi, *Sow.*
Limopsis aurita, *Broc.*
„ pygmæa, *Phil.*
*Loripes divaricatus, *L.*
*Lucina borealis, *L.*
Lucinopsis Lajonkairii, *Payr.*
Lutraria elliptica, *Lam.*
*Mactra arcuata, *Sow.*
* „ constricta, *Wood.*
„ glauca, *Born.*
„ solidissima, *Chem.* = M. procrassa, *Wood.*
* „ stultorum, *L.*
* „ solida, *L.*
* „ elliptica, *Brown.*
„ truncata.
* „ subtruncata, *Da Costa.*
Modiolaria costulata, *Risso.*
„ marmorata, *E. Forb.*
„ Petagnæ, *Scac.*
Montacuta bidentata, *Mont.*
„ ovata, *Jeffr.*
*Mya arenaria, *L.*
*Mya truncata, *L.*
*Mytilus edulis, *L.*
„ hesperianus, *Lam.*
* „ modiolus, *L.*
„ phaseolina, *Phil.*
„ barbata, *L.*
*Nucula Cobboldiæ, *Sow.*
* „ lævigata, *Sow.*
* „ nucleus, *L.*
* „ tenuis, *Mont.*
„ radiata, *Hanley.*
Ostrea cochlear, *Poli.*
* „ edulis, *L.*
„ princeps, *Wood.*
Pandora obtusa, *Leach.*
„ rostrata, *Lam.*
Panopea faujasii, *Men.*
„ *(var.)* Rudolphii, *Eichw.*
„ fragilis, *Nyst.*
*Pecten dubius, *Broc.*
* „ princeps, *Sow.*
* „ Maximus, *L.*
* „ opercularis, *L.*
* „ *var.* Audouinii, *Payr.*
* „ „ gracilis, *Wood.*
*Pecten pusio, *L.*
* „ tigrinus, *Penn.*
„ Westendorpianus, *Nyst.*
„ septemradiatus, *Müll.*
*Pectunculus glycimeris, *L.*
„ pilosus, *L.*
Pholadidea papyracea, *Sol.*
*Pholas crispata, *L.*
„ cylindrica, *Sow.*
„ dactylus, *L.*
„ parva, *Penn.*
*Pinna rudis, *L.*
Psammobia Ferroënsis, *Chemn.*
*Saxicava arctica, *L.*
* „ Norvegica, *Spengl.*
*Scrobicularia piperita, *Gmel.*
*Serripes Greenlandicus.
Solecurtus antiquatus, *Penn.*
*Solen ensis, *L.*
* „ siliqua, *L. var.* gladiolus, *Gray.*
„ pellucidus, *Penn.*
*Syndosmya alba, *W. Wood.*
*Tapes texturata, *Lam.*
„ pullastra, *W. Wood.*
* „ virginea, *L.*
Tellina Benedenii, *Nyst.*
* „ crassa, *Penn.*
* „ calcarea, *Chemn.*
* „ obliqua, *Sow.*
* „ prætenuis, *Leathes.*
Teredo Norvegica, *Spengl.*
*Thracia inflata, *Sow.*
* „ papyracea, *Poli.*
Venerupis irus, *L.*
Venus casina, *L.*
* „ fasciata, *Don.*
„ imbricata, *Sow.*
* „ ovata, *Penn.*
Woodia digitaria, *L.*

Brachiopoda.

*Terebratula grandis, *Blum.*

Land and Fresh Water Mollusca.

Helix rysa, *Wood.*
*Paludina parilis, *Wood.*
*Corbicula fluminalis, *Müll.*

Polyzoa.

Alecto dilitans, *Thomp.*
„ repens, *Wood.*
Alveolaria semiovata, *Busk.*
Alysidota labrosa, *Busk.*
Biflustra delicatula, *Busk.*
Cellepora parasitica, *Michel.*
„ scruposa, *Busk.* (?)
„ cespitosa, *Busk.*
„ compressa, *Busk.*
„ edax, *Busk.*
Diastopora simplex, *Busk.*

Discoporella grignonensis, *M. Edw.*
„ hispida, *Johnst.*
Eschara monilifera, *M. Edw.*
„ porosa, *M. Edw.*
„ Sedgwicki, *M. Edw.*
„ sinuosa, *Busk.*
Fascicularia aurantia, *M. Edw.*
„ tubipora, *Busk.*
Hemeschara imbellis, *Busk.*
Heteropora pustulosa, *Busk.*
Heteroporella radiata, *Busk.*
Hippothoa abstersa, *Wood.*
Hornera frondiculata, *Lamx.*
„ infundibulata, *Busk.*
„ rhomboidalis, *Busk.*
„ striata, *M. Edw.*
Lepralia ansata, *Johnst.*
„ infundibulata, *Busk.*
„ lobata, *Busk.*
„ Peachii, *Johnst.*
„ puncturata, *Wood.*
„ violacea, *Johnst.*
Lunulites conica, *Defr.*
Melicerita Charlesworthii, *M. Edw.*
Membranipora dubia, *Busk.*
„ monostachys, *Busk.*
„ oblonga, *Busk.*
„ Pouillettii, *Aud.*
„ Savartii, *Aud.*
„ trifoliata, *Wood.*
„ tuberculata, *Bosc.*
Reptomulticava macropora, *D'Orb.*
Salicornaria crassa, *Wood.*
„ sinuosa, *Hass.*
Tubulipora phalangea, *Couch.*
„ flabellaris, *Fabr.*

COELENTERATA.

Balanophyllia calyculus, *Wood.*
Cryptangia Woodii, *M. Edw.*
Flabellum. (? n. sp.)
Sphænotrochus intermedius, *Münst.*
Solenastrea Prestwichii, *Dunc.*

FORAMINIFERA.

Biloculina elongata, *D'Orb.*
„ ringens, *Lam.*
Calcarina rarispina, *D'Orb.*
Discorbina Parisiensis, *D'Orb.*
Lagena marginata, *W. & J.*
„ sulcata, *Mont.*
Nonionina faba, *F. & M.*
„ scapha, *F. & M.*
Polymorphina complanata, *D'Orb.*
„ gibba, *D'Orb.*
„ lactea, *W. & J.*
Polystomella crispa, *L.*
Polystomella striato punctata, *F. & M.*
Pullenia sphæroides, *D'Orb.*
Quinqueloculina seminulum, *L.*
Rotalia Beccarii, *L.*
Textularia sagittula.
Truncatulina lobatula, *W. & J.*
„ refulgens, *Montf.*
Uvigerina irregularis, *Brady.*

PLANTÆ.

Woods of three species of Angiospermous Dicotyledons, one Conifer, and two palms.

UPPER CRAG.

* These occur also in the Norwich or Fluvio-marine Crag. † Only found in the same. No Mammals are recorded from the purely marine beds of this age. ** Species common to the Middle and Norwich Crags only.

MAMMALIA.

TERRESTRIAL.
Arvicola amphibia, *Desm.*
„ campestris.
Bos.
Bison priscus.
Canis vulpes, *L.*
Castor fiber, *L.*
„ trogontherium, *Cuv.*
Cervus ardeus.
„ Falconeri, *Dawk.*
Elephas meridionalis, *Nesti.*
Equus caballus, *L.*
„ plicidens (?) *Owen.*
Felis catus, *L.*
Felis pardoides, *Owen.*
Hyæna antiqua, *Lank.*
Hipparion, sp.
Lepus cuniculus, *L.*
Lutra vulgaris.
Mastodon arvernensis, *Croizet.*
Ursus, sp.

MARINE.
Balæna, 2 sp.
Phoca vitulina, *L.*

AVES.

Various bones, sp. indet.

PISCES.

†Esox lucius.
Lamna, sp.
Merlangus pollachius, *Cuv.*
Morrhua vulgaris, *Cuv.*
*Platax Woodwardi, *Ag.*

*Raia antiqua, *Ag.*
„ sp.

CRUSTACEA.

Cancer pagurus, *L.*
Carcinus mænas, *L.*

CIRRIPEDIA.

*Balanus crenatus, *Brug.*
* „ dolosus, *Darw.*
* „ Hameri, *Asc.*
* „ porcatus, *Da Costa.*
„ tintinnabulum, *L.*

ANNELIDA.

Ditrupa gadus, *Mont.*
Sabellaria conchilega, *Pall.*

ECHINODERMATA.

*Echinocyamus pusillus, *Müll.*
Spatangus purpureus, *Müll.*
Toxopneustes Drobachiensis, *Müll.*

GASTEROPODA.

*Admete viridula, *Fabr.*
Amaura candida, *Möll.*
*Aporrhais pespelicani, *L.*
*Buccinum ciliatum, *Fabr.*
* „ Greenlandicum, *Chemn.*
* „ undatum, *L.*
*Buccinopsis Dalei, *Sow.*
*Calyptrea Chinense, *L.*
Cancellaria varicosa, *Broc.*
*Capulus Hungaricus, *L.*
„ militaris, *Wood*, non *Mont.*
„ unguis, *Sow.*
*Cassidaria bicatenata, *Sow.*
*Cerithiopsis tuberculare, *Mont.*
Cerithium granosum, *Wood.*
„ reticulatum, *Da Costa.*
* „ tricinctum, *Broc.*
„ variculosum, *Nyst.*
Chiton, sp.
Columbella abbreviata, *A. Bell.*
* „ sulcata, *Sow.*
„ Borsoni, *Bellardi.*
Conopleura crassa (?) *A. Bell.*
„ elegans (?), *Scac.*
*Cypræa avellana, *Sow.*
* „ Europea, *Mont.*
„ retusa, *Sow.*
*Defrancia linearis, *Mont.*
„ reticulata, *Ren.*
„ purpurea, *Mont.*
Emarginula fissura, *L.*
Erato lævis, *Don.*
„ Maugeriæ, *Gray.*
**Eulima polita, *L.*
*Fissurella græca, *L.*
Fusus altum, *Wood.*
„ antiquus, *L.*
„ contrarius, *L.*
„ cordatus, *A. Bell.*
Fusus costifer, *Sow.*
„ despectus, *L.*
„ gracilis, *Da Costa.*
** „ Norvegicus, *Chemn.*
„ Largillierti, *Fisch.*
Fusus Sarsii, *Jeffr.*
„ Turtoni, *Bean.*
**Hydrobia ulva, *Penn.*
„ ventrosa, *Mont.*
Lachesis, n. sp.
*Lacuna crassior, *Mont.*
* „ divaricata, *Fabr.*
Lepeta cæca, *Müll.*
*Littorina littorea, *L.*
* „ rudis, *Maton.*
„ suboperta, *Wood.*
* „ tenebrosa, *Mont.*
**Melampus myosotis, *Drap.*
*Murex erinaceus, *L.*
* „ tortuosus, *Sow.*
Nassa ascanias, *Brug.*
„ elegans, *Leathes.*
„ granulata, *Sow.*
* „ incrassata, *Strom.*
„ labiosa, *Sow.*
„ monensis, *E. Forb.*
* „ propinqua, *Sow.*
„ pygmæa, *Lam.*
* „ reticosa, *Sow.*
„ variabilis, *Phil.*
*Natica affinis, *Gmel.*
* „ borealis, *Gray.*
* „ Alderi, *E. Forb.*
* „ catena, *Da Costa.*
* „ catenoides, *Wood.*
* „ Greenlandicus, *Beck.*
* „ hemiclausa, *Sow.*
* „ Islandica, *Gmel.*
* „ multipunctata, *Wood.*
„ Montagui, *E. Forb.*
„ occlusa, *Wood.*
**Melampus myosotis, *Drap.*
* „ pyramidalis, *Sow.*
* „ fusiformis, *Wood.*
**Odostomia conoidea, *Broc.*
**Chemnitzia lactea, *L.*
„ communis, *Risso.*
* „ internodula, *Wood.*
„ plicatula, *Broc.*
*Ovula spelta, *L.*
„ Adriatica, *Sow.*
Paludestrina pendula, *Wood.*
Patella vulgata, *L.*
*Pleurotoma bicarinata, *Couth.*
„ Bertrandi, *Payr.*
„ contigua, *Broc.*
„ costata, *Don.*
* „ exarata, *Möll.*
* „ harpularia, *Couth.*
* „ mitrula, *Sow.*
* „ nobilis (?) *Möll.*
† „ pyramidalis, *Strom.*
„ pygmæum, *Phil.* (?)
„ rufa, *Mont.*
„ striolata, *Scac.*
„ galerita, *Phil.*

†Pleurotoma Trevelyana, *Turt.*
* ,, turricula, *Mont.*
,, violacea, *Mighels.*
,, volvula, *A. Bell.*
*Purpura lapillus, *L.*
* ,, tetragona, *Sow.*
Ringicula auriculata, *Men.*
,, ventricosa, *Sow.*
Rissoa confinis, *Wood.*
* ,, pulchella, *Wood* non *Phil.*
* ,, curticosta, *Wood.*
*Scalaria clathratula, *Mont.*
* ,, foliacea, *Sow.*
* ,, Greenlandica, *Chemn.*
,, subulata, *Nyst.*
,, varicosa, *Lam.*
(*) ,, Trevelyana, *Leach.*
*Tectura virginea, *Müll.*
,, parvula, *Wood.*
Terebra inversa, *Nyst.*
Trochus Adansoni, *Payr.*
,, cinerarius, *L.*
,, cineroides, *Wood.*
* ,, granulatus, *Born.*
,, Kickxii, *Nyst.*
,, multigranus, *Wood.*
,, Montacuti, *W. Wood.*
,, occidentalis, *Migh.*
,, subexcavatus, *Wood.*
* ,, tumidus, *Mont.*
,, villicus, *Phil.*
* ,, zizyphinus, *L.*
†(Margarita) Greenlandicus, *Chemn.*
*Turritella communis, *Risso.*
,, incrassata, *Sow.*
* ,, planispira, *Wood.*
*Trophon Barvicense, *Johnst.*
,, clathratum, *Mull.*
,, muricatum, *Mont.*
* ,, scalariforme, *Gould.*
†Velutina lævigata, *Penn.*
† ,, lanigera, *Möll.*
† ,, zonata, *Gould.*
Vermetus subcancellatus, *Biv.*
*Voluta Lamberti, *Sow.*

SOLENOCONCHA.

Dentalium dentalis, *L.*

OPISTHOBRANCHIATA.

*Actæon tornatilis, *L.*
* ,, subulata, *Wood.*
†Cylichna alba, *Brown.*
* ,, cylindracea, *Penn.*
Utriculus obtusus, *Mont.*

LAMELLIBRANCHIATA.

*Anomia ephippium, *L.*
* ,, patelliformis, *L.*
Arca lactea, *L.*
,, tetragona, *Poli.*
†Astarte borealis, *Chemn.*
* ,, Burtinii, *La Jonk.*
* ,, compressa, *Mont.*
† ,, elliptica, *Brown.*
* ,, gracilis, *Munst.*
Astarte Galeottii, *Nyst.*
* ,, Omalii, *La Jonk.*
,, obliquata, *Sow.*
,, sulcata, *Da Costa.*
*Cardita corbis, *Phil.*
* ,, scalaris, *Leathes.*
* ,, senilis, *Lam.*
*Cardium angustatum, *Sow.*
,, decorticatum, *Wood.*
,, echinatum, *L.*
* ,, edule, *L.*
,, interruptum, *Wood.*
,, Nodosum, *Turt.*
,, Parkinsonii, *Sow.*
,, venustum, *Wood.*
*Corbula gibba, *Olivi.*
Corbulomya complanata, *Sow.*
*Cyprina Islandica, *L.*
,, rustica, *Sow.*
*Diplodonta astartea, *Nyst.*
,, dilatata, *Wood.*
* ,, rotundata, *Mont.*
Donax vittatus, *Da Costa.*
,, trunculus, *L.*
Erycina ovata, *Phil.*
Gastrana laminosa, *Sow.*
Gastrochæna dubia, *Penn.*
*Glycimeris angusta, *Nyst.*
**Hinnites giganteus, *Carp.*
*Leda lanceolata, *Sow.*
* ,, myalis, *Couth.*
* ,, hyperborea, *Lov.*
** ,, semistriata, *Wood.*
*Loripes divaricatus, *L.*
*Lucina borealis, *L.*
*Mactra arcuata, *Sow.*
* ,, constricta, *Wood.*
* ,, stultorum, *L.*
* ,, solida, *L.*
* ,, elliptica, *L.*
* ,, subtruncata, *Da Costa.*
*Mya arenaria, *L.*
* ,, truncata, *L.*
*Mytilus edulis, *L.*
* ,, modiolus, *L.*
*Nucula Cobboldiæ, *Sow.*
* ,, Lyallii, *Baird.*
* ,, lævigata, *Sbz.*
* ,, nucleus, *L.*
* ,, tenuis, *Mont.*
*Ostrea edulis, *L.*
Pecten dubius, *Broc.*
** ,, Gerardii, *Nyst.*
** ,, princeps, *Sow.*
* ,, maximus, *L.*
* ,, opercularis, *L.*
* ,, var. Audouinii, *Payr.*
,, pusio, *L.*
* ,, tigrinus, *Müll.*
*Pectunculus glycimeris, *L.*
†Pholas candida, *L.*
* ,, crispata, *L.*
Pinna rudis, *L.*
*Saxicava arctica, *L.*
,, Norvegica, *Spengl.*
Scacchia elliptica, *Phil.*

*Scrobicularia piperita, *Gmel.*
*Serripes Greenlandicus, *Chemn.*
*Solen siliqua, *L.*
*Syndosmya alba, *W. Wood.*
†Tapes aureus, *Gmel.*
** „ texturata, *Lam.*
** „ virginea, *L.*
*Tellina calcarea, *Chemn.*
„ crassa, *Penn.*
** „ donacina, *L.*
† „ fabula, *Gron.*
* „ obliqua, *Sow.*
* „ prætenuis, *Leathes.*
**Thracia inflata, *Sow.*
* „ papyracea, *Poli.*
*Venus fasciata, *Don.*
* „ ovata, *Penn.*
Artemis exoleta, *L.*
** „ lincta, *Pult.*
*Cytherea rudis, *Poli.*
*Woodia digitaria, *L.*

BRACHIOPODA.

Argiope cistellula, *Wood.*
*Rhynchonella psittacea, *Chemn.*
Terebratula grandis, *Blum.*

POLYZOA.

Cellepora compressa, *Busk.*
Eschara sinuosa, *Busk.*
Fungella multifida, *Busk.*
Hornera infundibulata, *Busk.*
Lunulites conica, *Defr.*

CŒLENTERATA.

Balanophyllia calyculus, *Wood.*
Sphænotrochus intermedius, *Münst.*

SPONGIDA.

Clione celata, *Grant.*

FORAMINIFERA.

Bulimina aculeata, *D'Orb.*
Discorbina rosacea, *D'Orb.*
Globigerina bulloides, *D'Orb.*
Nodosaria raphanus, *L.*
Polymorphina compressa, *D'Orb.*
Polystomella crispa, *L.*
„ striato-punctata, *F. & M.*
Pulvulina Karstenii, *Reuss.*
Rotalia Beccarii, *L.*
Truncatulina lobatula, *W. & J.*

LAND AND FRESHWATER MOLLUSCA.

Ancylus lacustris, *L.*
†Bithynia tentaculata, *L.*
†Carychium minimum, *Müll.*
†Helix arbustorum, *L.*
† „ concinna, *Jeffr.*
* „ hispida, *L.*
* „ pulchella, *Müll.*
*Limnæus palustris, *Müll.*
„ var. Holbollii, *Müll.*
* „ peregra, *Müll.*
* „ truncatula, *Müll.*
„ stagnalis ? *L.*
**Paludina parilis, *Wood.*
Planorbis albus, *Müll.*
* „ complanatus, *L.*
„ corneus, *L.*
„ spirorbis, *Müll.*
*Pupa muscorum, *L.*
†Vertigo edentula, *Jeffr.* (?)
†Succinea oblonga, *Drap.*
„ putris, *L.*
†Valvata cristata, *Müll.*
† „ piscinalis, *Müll.*
**Corbicula fluminalis, *Müll.*
†Pisidium amnicum, *Müll.*
„ var. sulcatum, *Sow.*
†Sphærium corneum, *L.*

CHILLESFORD SERIES.

MAMMALIA.

Arvicola amphibia, *Desm.*
Mastodon arvernensis, *Croizet.*
Cervus.
Elephas.
Balæna, 2 spec.

PISCES.

Otolites, vertebræ (2 sp.), &c.

CRUSTACEA.

Claws.

CIRRIPEDIA.
Balanus balanoides (?)
„ crenatus, *Brug.*
„ porcatus.

ANNELIDA.

Serpula vermicularis, *L.*
Sabellaria conchilega, *Pall.*

ECHINODERMATA.

Echinus lividus, *Müll.*
Echinocyamus pusillus, *Müll.*
Spatangus purpureus, *Müll.*

GASTEROPODA.

Admete viridula, *Fabr.*
Buccinum Greenlandicum, *Chemn.*
„ undatum, *L.*
Buccinopsis Dalei, *Sow.*
Calyptræa Chinense, *L.*
Capulus Hungaricus, *L.*

Cerithium tricinctum, *Broc.*
Chemnitzia internodula, *Wood.*
Defrancia linearis, *Mont.*
Fusus antiquus, *L.*
(Trophon) muricatum, *Mont.*
Hydrobia ulvæ, *Penn.*
Lacuna divaricata, *Fabr.*
Littorina littorea, *L.*
„ rudis, *Mont.*
Melampus pyramidalis, *Sow.*
Nassa labiosa, *Sow.*
„ incrassata, *Strom.*
„ propinqua, *Sow.*
„ reticosa, *Sow.*
Natica Alderi, *E. Forb.*
„ affinis, *Gmel.*
„ borealis, *Gray.*
„ catena, *Da Costa.*
„ catenoides, *Sow.*
„ Islandica, *Gmel.*
„ hemiclausa, *Sow.*
„ millepunctata, *Wood.*
„ occlusa, *Wood.*
„ Spitzbergensis, *A. Bell.* (M.S.)
Odostomia.
Pleurotoma elegans, *Möll.* (?)
„ exarata, *Möll.*
„ harpularia, *Möll.*
„ nobilis, *Möll.*
„ Trevelyana, *Turt.*
„ turricula, *Mont.*
Purpura lapillus, *L.*
„ tetragona, *Wood.*
Ringicula auriculata, *Men.*
„ ventricosa, *Sow.*
Rissoa Stefanisi, *Jeffr.*
„ striata, *Ad.*
Scalaria pseudoscalaris, *Broc.*
„ foliacea, *Sow.*
„ Greenlandica, *Chemn.*
„ Trevelyana, *Leach.* (?)
„ Turtonis, *Leach.*
Trochus tumidus, *Mont.*
Turritella communis, *Risso.*
„ incrassata, *Sow.*
Voluta Lamberti, *Sow.*

OPISTHOBRANCHIATA.

Actæon tornatilis, *L.*
„ subulata, *Wood.*
Utriculus obtusus, *Mont.*
„ truncatulus, *Brug.*

LAMELLIBRANCHIATA.

Anomia ephippium, *L.*
„ patelliformis, *L.*
„ striata, *Broc.*
Astarte borealis, *Chemn.*
„ compressa, *Mont.*
„ sulcata, *Da Costa.*
Axinus flexuosa, *Mont.*
Cardita analis, *Phil.*
„ chamæformis, *Leathes.*
„ scalaris, *Leathes.*
Cardium edule, *L.*
„ fasciatum, *Mont.*
Cardium nodosum, *Turt.*
„ elegantulum, *Möll.*
Circe minima, *Mont.*
Cochlodesma complanata, *Wood.*
„ prætenue, *Pult.*
Corbula gibba, *Olivi.*
Cyprina Islandica, *L.*
Diplodonta rotundata, *Mont.*
Donax vittatus, *Da Costa.*
Erycina ovata, *Phil.*
Kellia ambigua, *Nyst.*
Leda hyperborea, *Lov.*
„ lanceolata, *Sow.*
„ myalis, *Couth.*
„ pygmea, *Münst.*
Lepton nitidum, *Turt.*
Loripes divaricatus, *L.*
Lucina borealis, *L.*
Lucinopsis undata, *Penn.*
Mactra arcuata, *Sow.*
„ elliptica, *Br.*
„ solida, *L.*
„ subtruncata, *Da Costa.*
Modiolaria discors, *L.*
„ marmorata, *E. Forb.*
Montacuta bidentata, *Mont.*
„ ferruginosa, *Mont.*
„ substriata, *Mont.*
Mya arenaria, *L.*
„ truncata, *L.*
Mytilus edulis, *L.*
„ modiolus, *L.*
Nucula Cobboldiæ, *Sow.*
„ nucleus, *L.*
„ tenuis, *Mont.*
Ostræa edulis, *L.*
Panopæa fragilis, *Nyst.*
Pecten Gerardi, *Nyst.*
„ opercularis, *L.*
„ pusio, *L.*
„ princeps, *Sow.*
„ tigrinus, *Mull.*
Pectunculus glycimeris, *L.*
Pinna rudis (?), *L.*
Saxicava arctica, *L.*
„ Norvegica, *Spengl.*
Scrobicularia piperita, *Gmel.*
Serripes Greenlandicus, *Chemn.*
Solen ensis, *L.*
„ pellucida, *Penn.*
„ siliqua, *L.*
Syndosmya alba, *W. Wood.*
„ prismatica, *Mont.*
Tellina calcarea, *Chemn.*
„ crassa, *Penn.*
„ donacina, *L.*
„ fabula, *Gron.*
„ obliqua, *Sow.*
„ prætenuis, *Leathes.*
Thracia papyracea, *Poli.*
„ var. villosiuscula, *McG.*
Venus ovata, *Penn.*

BRACHIOPODA.

Rhynchonella psittacea, *Gmel.*

POLYZOA.

Alveolaria semiovata, *Busk.*
Membranipora monostachys, *Busk.*
Salicornaria sinuosa, *Hassall.*

SPONGIDA.

Clione celata, *Grant.*

FORAMINIFERA.

Bulimina elegans, *D'Orb.*
Polystomella crispa, *L.*
„ striato-punctata, *F. & M.*
Polymorphina lactea, *W. & J.*
Rotalia Beccarii, *L.*
Truncatulina lobatula, *W. & J.*

LAND AND FRESHWATER MOLLUSCA.

Helix arbustorum, *L.*
„ hispida, *L.*
Linnæus pereger, *Müll.*
„ truncatulus, *Müll.*
„ palustris, *Müll.*
Paludina parilis, *Wood.*
Planorbis complanatus, *L.*
Valvata piscinalis, *Müll.*
Corbicula fluminalis, *Müll.*
Pisidium amnicum, *Müll.*
Sphærium corneum, *L.*

FOREST BED.

MAMMALIA.

Arvicola amphibia, *Desm.*
Asinus fossilis, *Owen.*
Bison priscus, *Owen.*
Bos primigenius, *Blum.*
Castor fiber, *L.*
„ trogontherium, *Cuv.*
Cervus ardeus, *Falc.*(?)
„ bovoides, *Gunn.*
„ Capreolus ? *L.*
„ megaceros, *Harte.*
„ elaphus, *L.*
„ Sedgwickii, *Gunn.*
„ Poligniacus.
„ Gunni (?) *
Elephas antiquus, *Falc.*
„ var. priscus, *Goldf.*
„ meridionalis, *Neste.*
„ leptodon, Gunn *(M. S.)*
„ giganteus, G. *(M. S.)*
Equus caballus, *L.*
Hippopotamus major, *Desm.*
Hyæna spelæa, *Geoffr.*
Ovis vel Capra.
Machairodus latidens.
Monoceros monodon, *L.*
Mus musculus, *L.*
Mygale moschata, *Pall.*
Rhinoceros megarhinus, *De Christol.*
„ etruscus, *Falc.*
(Sciurus sp.†)
Sorex fodiens, *Gmel.*
„ remifer, *Geoff.*
Sus arvernensis.
Talpa Europæa, *L.*
Ursus arvernensis, *C. & J.*
„ spelæus, *Goldf.*
„ etruscus.
Balæna, two sp.
Trichecus rosmarus, *L.*

AVES.

Bones, sp. indet.

PISCES.

Esox lucius, *L.*
Perca fluviatilis, *L.*

INSECTA.

Donacia linearis.
„ (several sp. indet).
Oiceoptoma dispar.

GASTEROPODA.

Ancylus fluviatilis, *Müll.*
„ lacustris, *L.*
Bithynia tentaculata, *L.*
Carychium minimum, *Müll.*
Helix arbustorum, *L.*
„ concinna, *Jeffr.*
„ hispida, *L.*
„ nemoralis, *L.*
Limax agrestis, *Müll.*
Limnæa palustris, *Müll.*
„ pereger, *Müll.*
„ stagnalis, *Müll.*
Paludina contecta, *Müll.*
Physa fontinalis, *Müll.*
Planorbis albus, *Müll.*
„ complanatus, *L.*
„ corneus, *L.*
„ nautileus.
„ nitidus.
Succinea oblonga, *Drap.*
„ putris, *L.*
Valvata piscinalis, *Müll.*
„ var. antiqua, *Sow.*
„ cristata, *Müll.*
Zua lubrica, *Müll.*

* The terminal portion of an antler so named is in the King Collection, Museum of Practical Geology.

† Indicated by the bitten fir cones. No remains of the animal are known.

LAMELLIBRANCHIATA.

Anodonta cygnea, *L.*
„ anatina, *L.*
Pisidium amnicum, *Müll.*
„ var. sulcatum, *Sow.*
„ fontinale, *Drap.*
„ Henslowiana, *Shepp.*
„ nitidum, *Jenyns.*
Sphærium corneum, *L.*
„ rivicola, *Leach.*
Unio littoralis, *Lam.*
„ pictorum, *L.*

PLANTÆ.

Alnus glutinosa, *Gærtn.*
Ceratophyllum demersum, *Smith.*
Corylus avellana, *L.*
Menyanthes trifoliata, *L.*
Nuphar lutea, *Smith.*
Nymphæa alba, *L.*
Osmunda regalis, *L.*
Potamogeton lucens, *L.*
Pinus abies, *L.*
„ sylvestris, *L.*
Prunus spinosus.
Quercus—
Salix, sp.
Taxus baccatus, *L.*
Ulmus, sp.
Also Rhizomes and fronds of Ferns.

We have to thank the Rev. J. Gunn, M.A., F.G.S., for kindly revising the lists of the Vertebrata of the Forest Bed, thus ensuring their correctness.

The *Monoceros* (Narwhal) came from the sands immediately overlying the Forest Bed; we have, however, thought it advisable to leave it in the list.

Elephas leptodon and *E. giganteus* are founded upon some molar teeth and immense bones not yet described.

Cervus bovoides is founded upon one of the most remarkable fossils yet discovered in this ancient cemetery, *i.e.*, " a large antler"—" first supposed to have belonged to an ox, but subsequently proved to be that of a deer."

NOTE BY ALFRED BELL.

The foregoing lists by no means exhaust the faunas of the various deposits. I had hoped to have added to them the species that will shortly be described in the Palæontographical Society's twenty-fifth volume, but the delay in publication renders this imposible. I have also notes of many species still undescribed, including Echini, Molluscs, and Polyzoa, and I would especially recommend any collector not to throw away anything, even a fragment, without first ascertaining what it is. A fauna can be determined only by patient examination, and I do not know any pleasure in collecting that gives greater zest to a student than in finding out that a deposit already well worked, still yields fresh novelties. Fresh sections are very likely to produce these, as I have found by experience, and the sections of five years ago had very often a fauna different from what they have at present.

If any of the members of the Geologists' Association are in possession of any forms that may be undescribed, I beg the favour of seeing them, for I find in most collections something new when the geologist has collected for himself; and I am desirous of completing, as far as possible, the record of the organic remains contained in the English Crags.

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2. On South African Diamonds. By Professor JAMES TENNANT, F.G.S., F.C.S., F.R.G.S., &c.

(The publication of this Paper is deferred.)

EXCURSION TO CAMBRIDGE, April 10th and 11th, 1871.

Directors—The President; Professor Morris, F.G.S.; The Rev. T. G. Bonney, M.A., F.G.S., &c.; and Harry G. Seeley, Esq., F.G.S.

The Members left London at an early hour, and on arriving at Cambridge, proceeded at once to the Woodwardian Museum, where they were met by the Rev. Dr. Cookson, Master of St. Peter's College; the Rev. Thomas Wiltshire, M.A., F.G.S., &c., President of the Association; Professor Morris, F.G.S., H.M.G.A.; the Rev. T. G. Bonney, M.A., F.G.S., Fellow and Tutor of St. John's College; the Rev. Osmond Fisher, M.A., F.G.S., late Fellow and Tutor of Jesus College; and Harry G. Seeley, Esq., F.G.S., as the representative of the venerable Professor Sedgwick, who, much to his regret, was prevented being present.

The collection of Fossil Mollusca was ably described by the Rev. T. G. Bonney, M.A., who directed the attention of the visitors more especially to the illustrations of the palæontology of the neighbourhood of Cambridge. In this collection are preserved very fine examples of the Brachiopoda found recently so abundantly in the phosphatic Lower Greensand strata at Upware.

Mr. Harry Seeley then in an interesting discourse described the Cambridgeshire Reptilian Remains, which form a valuable portion of the Woodwardian Museum. It was pointed out that the Pterodactyles, though in some points essentially reptiles, presented curious affinities both to birds and mammals. Thus while the most fundamental part of the skeleton, the vertebrate column, is reptilian in its technical characters, the fore-limbs are those of a bird, and the femur that of a mammal. The brain cavity again is essentially that of a bird, while the bones of the face are reptilian. The Pterodactyles, the remains of which occur in the Cambridge Greensand, differ in some important respects from others. All others have at least four fingers on each hand, these have three at most, and the Cambridge Pterodactyles have only flexible tails. Remains of marine Chelonians (*Rhynchochelis*) were exhibited. These were stated to be generally allied in structure to living fresh-water species; but these alone, among Chelonians, have real nasal bones, hence the name given to the genus. Bones of birds allied to Penguin are also found. But perhaps the most interesting specimen shown was a vertebra of an

Oolitic whale, *Palæocetus*, which, if correctly determined, carries back the Placental Mammalia to a period in which their existence has been scarcely suspected, and almost gives encouragement to the expectation of Professor Jukes that the remains of mammals will some day be found in the Coal Measures. It was sufficiently wonderful to find Mammalian remains at all in the Stonesfield Slate, but these were those of small animals. How the bones of whales could so long be overlooked in Mesozoic strata is difficult to conceive.

Attention was drawn to a skull of *Bos primigenius*, found in the Fens, having an aperture through the bone and a flint implement inside.

Professor Morris then delivered, in the Geological Lecture Theatre, a lecture on the Geology of the Country around Cambridge.

The geological structure of the country around Cambridge is, he remarked, of considerable interest, both in regard to its influence on the physical features of the district, as well as on account of the economical substances obtained from the strata of the neighbourhood. The geological formations chiefly belong to the Cretaceous System and to the Upper and Middle Oolites, here and there covered by the later Pleistocene deposits. In descending order we find—

MODERN DEPOSITS...	River Alluvium and Fen-land.
PLEISTOCENE	Valley Gravels and Clays, with Mammalian Remains.
	Higher Gravels, with Flint and worn fragments of various rocks.
	Brown or Boulder Clay, with Chalk and various other rocks
CRETACEOUS	Lower Chalk and Chalk Marl.
	Upper Greensand. *(Coprolites).*
	Gault.
	Lower Greensand. *(Coprolites).*
OOLITIC	Kimmeridge Clay.
	Upware Limestone.
	Ampthill or Tetworth Clay.
	Elsworth Rock.
	Oxford Clay.

The Fen-lands, so well known in the Eastern Counties, commence near Cambridge, on the Gault, and further eastward are underlain by the Kimmeridge and Oxford Clays. The Valley Gravels bordering the Cam appear to be ancient river deposits, consisting of the re-arranged materials of the older gravels and Boulder Clay, and contain many land and river shells now living in the district, with two species, *Unio litoralis* and *Corbicula* (*Cyrena*) *fluminalis*, extinct in Britain, and associated with remains of *Elephas*, *Rhinoceros*, *Bos*, *Equus*, &c. The Higher Gravels and Boulder Clay, containing fragments of rocks brought from various distances, indicate that they have been drifted by currents of water or the action of ice, and hence are referred to the Glacial period. Of the two great divisions of the Chalk, the Lower Chalk only, with its characteristic fossils, is seen near Cambridge, the Upper Chalk forming the escarpment of the hills considerably to the east of Cambridge. The Upper Greensand, although of limited thickness, is well exposed at the numerous workings for phosphatic nodules; besides "coprolites" it has yielded the fine series of fossils now exposed in the Woodwardian Museum, including many species of Reptiles (Chelonians, Enaliosaurs, Pterodactyles, Crocodilians, Dinosaurs); Birds; Fish (20 or 30 species); many species of Brachiopoda, Lamellibranchiata, Gasteropoda, Cephalopoda, and Crustacea, as well as numerous Sponges, Corals, and Foraminifera. The Reptiles, especially the Ornithosauria, have been elaborately described by Mr. Harry Seeley. The Gault, or Cambridge brick earth, about 150 feet thick, extends over a wide area, and is well seen at Barnwell. It contains but few fossils, of which perhaps the *Belemnites minimus* is the species least rarely found. The Lower Greensand, exposed at Upware, and reached in deep sinkings below the town (this formation being here the source of an Artesian well water supply) is also worked, at Upware, for phosphatic nodules, but contains many fossils, chiefly Brachiopoda, palatal teeth of the fishes, *Sphærodus*, *Gyrodus*, &c., and bones of reptiles (*Iguanodon*), these latter being probably derived from some older deposits. At Potton, Bedfordshire, the Iguanodon remains are very abundant in a deposit of similar age. The Kimmeridge Clay, well seen at Ely, underlies the Lower Greensand, which latter deposit, however, is also unconformable to other formations in its range southwards and eastwards; this clay contains many fossils, remains of *Plesiosaurus* and *Pliosaurus*, and the usual characteristic shells, *Ostrea deltoidea*, *Ammonites biplex*, &c. The underlying strata of the Upware Limestone, Ampthill Clay, and Elsworth Rock, may possibly represent the Corallian Oolites of other districts, although Mr. H. Seeley sees good reason, from their fossil contents, for considering the Ampthill Clay only as the true representative of the Coral Rag. The Oxford Clay forming the great area of the Fen-land, is the lowest deposit seen within a limited distance from Cambridge. It is to be found at St. Neots, Huntingdon, &c., and contains many fossils. Besides the physical features and economical substances to be noted, it is worthy of remark that the geological structure of this district is favourable for a good water supply, since an abundant supply of water may be derived from springs above the Chalk Marl, from those rising above the Gault, from superficial gravels, and from Artesian wells sunk into the sands between the Gault and the Kimmeridge Clay.

The afternoon was devoted to a visit to the Coprolite Workings and other excavations at Barnwell. Proceeding along the banks of the Cam, a fine section of Pleistocene deposits, yielding Mammalian Remains, and the usual species of Mollusca, was examined. This exposure exhibits some beautiful examples of false bedding, and many granite and other boulders from the Drift were seen. Descriptions of this interesting section and its contents are given by the Rev. T. B. Brodie, M.A., in the "Transactions of the Philosophical Society of Cambridge," vol. viii., and by Mr. H. Seeley, in the "Quarterly Journal of the Geological Society," vol. xxii. The last mentioned paper contains a list of species collected by Mr. Dewick, to which Mr. Alfred Bell now adds the following:—*

Sphærium calyculata.	Ancylus lacustris.
Pisidium pulchellum.	Zonites radiatulus.
,, nitidum.	Helix fruticum.
Planorbis carinatus.	,, concinna.
Limnæa pereger.	,, rufescens.
,, truncatula.	,, pulchella.
,, palustris.	Pupa umbilicata.
,, auricularia.	

Mr. Bell writes, "The presence of so many species no longer living in Britain makes this an exceedingly interesting deposit. I refer to *Corbicula fluminalis*, *Unio littoralis*, *Hydrobia marginata*, *Helix fruticum*, *Helix ruderata?* and *Vertigo Moulinsiana*. No other fluviatile deposit that I am aware of contains such an assemblage." A very extensive excavation in the Gault, which is here capped by a thin deposit of Upper Greensand and Chalk, was next visited. The Gault, excavated for brick-making purposes, is exposed to a depth of seventy or eighty feet; and from the evidence of well-sinkers it is at this place, probably, from one hundred and fifty to two hundred feet thick. Fossils are rarely met with in the Gault at Barnwell,

* The Editor begs to express his obligations to Mr. Alfred Bell for his valuable note.

though in other localities this formation is very fossiliferous. Lying on the Gault, at its junction with the Upper Greensand beds before mentioned, occurs the stratum containing the phosphatic nodules, incorrectly called *coprolites,* for which this district is famous, and which, though from another locality, were first noticed as being valuable for agricultural purposes by the late Professor Henslow. At a short distance from this excavation the coprolite workings are found on all sides; indeed, the whole of the land is here being systematically explored for these valuable nodules, which lie at an average depth of six or seven feet from the surface. One field after another is taken in hand; the phosphatic bed of about twelve inches in thickness is removed; the soil is carefully replaced on the surface, and the field is then again ready for tillage. Upwards of £100 per acre is paid for the right of working these beds, the contractors being bound to replace the soil, which is generally found to have been improved by the overturning and exposure to which it has been subjected. The so-called coprolites are washed by horse-power, to remove the sand and loam in which they are embedded, and then they are ready for conversion into manure.* A considerable number of fossils, chiefly of Brachiopoda (*Terebratula biplicata* being most abundant), were obtained.

The party returned to Cambridge, and in the evening were most hospitably entertained at St. John's College, by the Rev. Mr. Bonney, M.A.

On the following day, Upware, between Cambridge and Ely, was visited. At this place, situated in the Fens, and near to the River Cam, very interesting sections have been exposed, in consequence of the search for phosphatic nodules. The Gault, which here becomes very thin, has been cut through, and Lower Greensand strata reached. At the base, as at the top of the Gault, curiously enough, a bed abounding in coprolites is found, and this bed contains characteristic Lower Greensand fossils, together with several new species of Brachiopoda, described by J. F. Walker, B.A., F.G.S. Cropping out within a very short distance from this exposure of Gault and Lower Greensand is a remarkable rock, full of fossil corals, which has hitherto been called Coral Rag, but which Mr. Harry Seeley, who has given great attention to the strata of this district, considers to be of Kimmeridgian age. This rock, to which Mr. Seeley has given the name of "Upware Limestone," is underlain

* See Proc. Geol. Asso., vol. i., p. 271.

by what that gentleman calls "Ampthill Clay," which would appear to be, in accordance with these views, the equivalent of the Coral Rag of Oxfordshire, Wiltshire, Dorsetshire, &c. The Brachiopoda in the infra-Gault coprolitic bed are abundant, especially *Terebratula sella*, *T. prælonga*, and *Waldheima*, or *Terebratella Davidsoni*, many fine specimens of each of which species were obtained, as well as numerous teeth of fishes and reptiles.

In a notice of the strata exposed at this locality, which appeared in the "Geological Magazine," vol. iv, p. 309, Mr. Walker gives the following details of the

SECTION AT UPWARE.

7. Surface, black peaty soil, often containing bones of red deer, horse, &c. . . .	about	1ft.	6in.
6. Layer of light-coloured Coprolites . .	„	1	0
5. Sand (called by the workmen Silt) . .	„	1	6
4. Vein of dark-coloured Coprolites . .	„	0	9
3. Silt	„	1	6
2. Vein of dark Coprolites . . .	„	1	0
1. Clay not pierced			

AT ANOTHER WORKING.

Sand	„	6	0
Coprolitic vein	„	2	0
Conglomerate (hard rock) . . .	„	0	4
Light-coloured Sand and Clay			

"The three layers of nodules noticed in the first section often become blended into one, but the top layer differs in the nodules being of a much lighter colour, and I was informed that they were less valuable.

"The hard rock (Conglomerate) consisting of nodules and pebbles, cemented together chiefly by carbonate of calcium, varies considerably, sometimes being so firm as to be penetrated with difficulty, at other times the coprolites near the clay are easily worked.

"The Kimmeridge Clay is not pierced, as there is no occasion for a well, the works being near the river. Among the nodules there are found phosphatic shells, as in the bed near Potton. They consist of fragments of Ammonites (and some of the nodules are marked by impressions of Ammonites), casts of Brachiopoda, Conchifera, and Gasteropoda, also remains of large Belemnites, and *Gryphœa dilatata*, composed of carbonate of calcium, occur, derived from the Oxford Clay."

From the lists given in the paper whence the above is taken, and from others since published by Mr. Walker, the following catalogue of fossils found in the calcareo-phosphatic Lower Greensand deposit of Upware has been compiled.

ORGANIC REMAINS FROM THE LOWER GREENSAND AT UPWARE.

SPONGIDA—
Manon macroptera.
Verticillites anastomosans, *Mant.*

POLYZOA—
Sp.

BRACHIOPODA—
Rhynchonella antidichotoma, *Buv.*
„ depressa, *Sow.*
„ Gibbsiana, *Sow.*
„ lata, *D'Orb.*
„ parvirostris, *Sow.*
Terebratella Fittoni, *Meyer.*
„ ? Davidsoni, *Walker.*
Terebratula Dallasii, *Walker.*
„ depressa, *Lam.*
„ var. Cantabrigensis.
„ var. Cyrta.
„ var. uniplicata.
„ Dutempleana, *D'Orb.*
„ extensa, *Meyer.*
„ Lankesteri, *Walker.*
„ Meyeri, *Walker.*
„ microtrema, *Walker.*
„ Moutoniana, *D'Orb.*
„ prælonga, *Sow.*
„ Seeleyi, *Walker.*
„ Sella, *Sow.*
„ Tornacensis, *D'Arch.* ?
Waldheimia celtica, *Morris.* ?
„ mutabilis, *Walker.*
„ pseudo-jurensis, *Leymerie.*
„ rhomboidea, *Walker.*
„ tamarindus, *Sow.*
„ Woodwardi, *Walker.*

LAMELLIBRANCHIATA—
Cardium, sp.
Cyprina, sp.
Janira neocomiensis, *D'Orb.*
Opis neocomiensis, *D'Orb.*
Ostrea macroptera, *Sow.*
„ sp.
Pecten Carteronianus, *D'Orb.*
„ Cottaldianus, *D'Orb.*
Plicatula Carteroniana, *D'Orb.*
„ sp.
Trigonia spinosa, *Park.*

GASTEROPODA—
Cerithium, sp.
Nerinea, sp.
Scalaria, sp.
Trochus, sp.
Turbo, sp.

CEPHALOPODA—
Ammonites, sp.
Belemnites, sp.

PISCES—
Asterocanthus ornatissimus, *Ag.*
Edaphodon.
Gyrodus.
Hybodus.
Psammodus reticulatus, *Ag.*
Pycnodus gigas ?
Sphærodus gigas, *Ag.*
Sphenonchus.

REPTILIA—
Dakosaurus.
Ichthyosaurus.
Iguanodon.
Plesiosaurus.
Pliosaurus.

Mr. Walker remarks that—" This bed and the conglomerate bed near Potton, appear to be of the same age, and probably, also, the Farringdon beds, viz., Lower Greensand, containing large numbers of fossils from other formations."

Mr. H. Keeping, the Assistant Curator of the Woodwardian Museum, Cambridge, has given an interesting section (" Geological

Magazine," vol. v., page 273), showing a "sequence from the Coral Rag to the Gault," of which the following are the details .—

Non-fossiliferous Gault, seven feet.
Phosphatic bed in Gault of five inches in thickness.
Gault of about one foot in thickness.
Upper layer of Lower Greensand.
Upper Phosphatic bed of Lower Greensand.
Lower Greensand, with few or no fossils.
Lower Phosphatic bed of Lower Greensand, rich in fossils, and often cemented, so as to form hard conglomerates, and containing a large quantity of derived fossils.
Pure Kimmeridge Clay.
Coral Rag, intermixed with Kimmeridge Clay.
Coral Rag *in situ*.

At a little distance from the Coprolite Workings, and very near to the outcrop of the "Coral Rag" (the "Upware Limestone" of Mr. H. Seeley), Mr. Keeping had an excavation made of about ten feet, cutting through the Gault, from which he derived the following species .—

Inoceramus concentricus, *Park.*
Nucula ovata, *Mant.*
" pectinata, *Sow.*
Dentalium ellipticum, *Sow.*
Ammonites interruptus
" serratus, *Park.*
Baculites
Belemnites attenuatus, *Sow.*
" minimus, *List.*

The drive back to Cambridge—twelve miles through "the Fens" —was quickly and agreeably accomplished, and the Members returned to London highly gratified by their instructive visit to Cambridgeshire.

VISIT TO THE HUNTERIAN MUSEUM OF THE ROYAL COLLEGE OF SURGEONS.

April 18th, 1871.

Director—Professor Morris, F.G.S.

The Museum of the Royal College of Surgeons, founded in 1787, by John Hunter, consists of two departments, the Physiological and the Pathological, and the collections forming these are contained in three spacious halls, named the Western, the Middle, and the Eastern Museums. It was to the Physiological Department that this visit was paid, and the attention of Members was chiefly directed to the specimens illustrating the distinguishing characters of those families and classes of the animal kingdom with which it is necessary for the student of palæontology to be familiar.

The Members assembled in the Western Museum, in which are contained the illustrations of invertebrate life. Professor Morris prefaced his descriptive lecture by an account of the origin of the Museum, and paid a high tribute of praise to the far-seeing mind of its great founder, who, although living in an age which knew not the modern science of geology, recognised the teaching of the organic remains which the rocks yield to the searcher for the stony records of the past.

The collections in the Physiological Department have been arranged by Professor Flower, the Conservator, in accordance with the most recent Zoological classification. The examples of the Invertebrata are displayed in ascending order. Commencing with the lowest type of animal existence, the Protozoa, we find beautiful specimens of sponges, and then we pass on to cases containing exquisite examples of the Cœlenterata. The Actinozoa is finely represented by specimens of Rugosa, Zoantharia, Alcyonaria, and Ctenophora. The Rugosa is especially interesting to geologists, since it is an extinct order, the Rugosa being only represented by fossil species, and these nearly exclusively Palæozoic. The most marked peculiarity of the Rugosa is that the species have either four divisions or cell walls, or a multiple of four, while the Zoantharia, found in secondary strata and abundantly represented by living species, have six, or a multiple of six, cell divisions. The other division of the Cœlenterata, the Hydrozoa, is also well represented, especially the Graptolitidæ, the family which has received so much elucidation from the researches of our two members, Mr. Carruthers and Mr. Hopkinson.

The Molluscoidea, comprising the three classes—Polyzoa or Bryozoa, the Tunicata, and the Brachiopoda—next attract attention by the beauty of the specimens and the effectiveness with which the anatomical structure of the Lingula and other genera of the Brachiopoda is displayed.

Amongst the examples of the Lamellibranchiata, the pearl-yielding species attracted great attention. Prof. Morris gave an interesting account of the formation of pearls, and showed that the mollusc can be made to produce pearls at the will of man, by the insertion of a foreign substance into the interior of the shell, when a nacreous incrustation forming a pearl will be speedily produced by a secretion from the animal.

The fairy-like forms of the Pteropoda are well exemplified in this Museum, and specimens of *Clio*, *Hyalea*, and *Cleodora*, preserved in spirits, are conspicuously displayed. It is difficult to believe that the huge whale, the enormous skeleton of one of which monsters of the deep is extended above, can be supported by small and delicate creatures like the *Clio borealis*, yet such is the fact, for Pteropods form the chief food of some whales.

After examining the illustrations of the Gasteropoda, both Branchiogasteropoda and Pulmogasteropoda, the visitors passed on to the cases containing examples of Cephalopoda. The Tetrabranchiata, now only represented by the *Nautilus*, is especially dear to geologists, for to this order does the *Ammonite*, the beloved of young geologists, belong.

To the other order of the Cephalopoda, the Dibranchiata, the *Belemnite* must be assigned, and the beautiful little internal shell, the *Spirula*, as well as the *Argonaut*, or the Paper Nautilus, and the shell-less *Octopus*. Subsequently attention was drawn to the Echinodermata, and the Crustacea, and the carefully disarticulated specimens, illustrating the structure of the hard external covering of these two important classes, were carefully observed.

After thus inspecting the types of the invertebrate classes of the animal kingdom, the party passed into the Middle Museum, where the collection of vertebrate fossils brought together by Hunter are preserved. The Eastern Museum was then visited, and the skeletons of the larger Mammalia, which are here finely displayed, formed the subject for the concluding remarks of the lecture by Professor Morris, to whom a cordial vote of thanks was tendered by the Members present.

EXCURSION TO BELVEDERE, April 29th, 1871.

Director—Professor Morris, F.G.S.

The object of this excursion was mainly to afford the Members of the Association an opportunity of inspecting the fine collection of Mammalian Remains in the possession of C. J. Spurrell, Esq., F.G.S., of Belvedere.

Professor Morris described this interesting collection in his usual happy manner. Almost all the specimens have been obtained from the Pleistocene fluviatile deposits of the immediate neighbourhood of Erith and Crayford. When, therefore, we find in this Museum remains of three species of elephant, three species of rhinoceros, and species of lion, bear, hyena, horse, and ox, we are forcibly reminded of the abundance of the larger animals, both Carnivora and Herbivora, with which the country surrounding London was peopled in pre-historic times. This collection is interesting, moreover, on account of the evidence it affords of great climatic alternations, for it contains species both of warm and of cold climates—the Lion of the Tropics and the *Ovibos moschatus* of the Arctic Zone.

Mammalian remains are not, however, the only records of the past which the deposits of the Thames Valley yield to the searcher for the "medals of creation." Many species of Mollusca which are now living in England have been found fossil in this locality together with *Corbicula* (*Cyrena*) *fluminalis*, which is not now living in the British area, but which is found flourishing at the present time in the waters of the Nile. Additional interest is given to this part of Kent by the existence of numerous caves or excavations in the Chalk. These curious and obscure cavities are locally termed "Grimes' Graves," and they have recently afforded considerable interest from certain investigations into their history and the purposes for which they were formed. They are evidently the work of man, and it is thought by some that they were excavated for the purpose of obtaining from the Chalk those flints which were of so much use and value to our pre-historic ancestors.

The following lists of the Mammalia occurring at each of five localities in the Thames Valley, are given on the authority of Mr. Boyd Dawkins, whose paper "On the Age of the Lower Brick-earths of the Thames Valley," in the "Quart. Journ. Geol. Soc.," vol. xxiii, p. 91, should be consulted.

ILFORD.

Arvicola amphibia, *Desm.*
Bison priscus, *Owen.*
Bos primigenius, *Boj.*
Canis lupus, *L.*
Castor fiber, *L.*
?Cervus capreolus, *L.*
,, elaphus, *L.*
Elephas antiquus, *Falc.*
,, primigenius, *Blum.*
Equus fossilis, *Owen.*
Felis spelæa, *Gold.*
Megaceros Hibernicus, *Owen.*
Rhinoceros leptorhinus, *Owen.*
,, megarhinus, *Christ.*
,, tichorhinus, *Cuv.*
Ursus arctos, *L.*
,, spelæus, *Gold.*

GRAYS THURROCK.

Arvicola amphibia, *Desm.*
Bison priscus, *Owen.*
Bos primigenius, *Boj.*
Canis lupus, *L.*
,, vulpes, *L.*
Castor fiber, *L.*
?Cervus capreolus, *L.*
,, elaphus, *L.*
Elephas antiquus, *Falc.*
,, priscus, *Gold.*
Equus fossilis, *Owen.*
Felis catus, *L.*
,, spelæa, *Gold.*
Hippopotamus major, *Desm.*
Hyæna spelæa, *Gold.*
Lutra vulgaris, *Erxl.*
Megaceros Hibernicus, *Owen.*
Rhinoceros leptorhinus, *Owen.*
,, megarhinus, *Christ.*
Sus scrofa, *L.*
Ursus arctos, *L.*
,, spelæus, *Gold.*

CRAYFORD.

Arvicola amphibia, *Desm.*
Bison priscus, *Owen.*
Bos primigenius, *Boj.*
Canis lupus, *L.*
Cervus elaphus, *L.*
Elephas antiquus, *Falc.*
,, primigenius, *Blum.*
Equus fossilis, *Owen.*
Felis spelæa, *Gold.*
Hyæna spelæa, *Gold.*
Megaceros Hibernicus, *Owen.*
Rhinoceros leptorhinus, *Owen.*
,, megarhinus, *Christ.*
,, tichorhinus, *Cuv.*
Ursus arctos, *L.*
,, spelæus, *Gold.*

ERITH.

Bos primigenius, *Boj.*
Canis lupus, *L.*
Elephas antiquus, *Falc.*
Elephas primigenius, *Blum.*
Equus fossilis, *Owen.*
Felis spelæa, *Gold.*

WICKHAM.

Bison priscus, *Owen.*
Bos primigenius, *Boj.*
Equus fossilis, *Owen.*
Rhinoceros leptorhinus, *Owen.*
,, tichorhinus, *Cuv.*

ORDINARY MEETING, May 5th, 1871.

The Rev. Thomas Wiltshire, M.A., F.G.S., &c., President, in the Chair.

The following Donations were announced:—

"Transactions of the Historic Society of Lancashire and Cheshire," vol. x., from that Society.

"Proceedings of the Berwickshire Naturalists' Field Club," 1870, from that Club.

"Abstract of Proceedings of the Geological Society," from that Society.

"Journal of the London Institution," from that Institution.

"Abstract of Proceedings of the Liverpool Geological Society," from that Society.

The following were elected Members of the Association:—

The Rev. E. S. Dewick, M.A.; James Horne, Esq.; Wilfred Hudleston Hudleston, Esq., J.P., M.A., F.G.S., F.C.S., &c.; and Earnest Ifill Shadbolt, Esq.

The following Paper was read:—

On Relics of the Carboniferous and other old Land-surfaces.

By Henry Woodward, Esq., F.G.S., F.Z.S.

Although unwilling to admit that in the history of our Earth special and peculiar conditions have prevailed at any period since the first advent of organic beings, yet we cannot doubt, that during peculiar eras, circumstances favoured the development of special groups of organisms which, in consequence, flourished in greater perfection and numbers than the rest.

Thus, in the earlier Palæozoic rocks Trilobites abounded; in the Secondary rocks, Ammonites; in the Tertiary, Nummulites; whilst the Carboniferous period was marked by its great development of Land Vegetation. Other land-floras we know, however, existed, both pre and post-Carboniferous, but, apparently, they did not attain to the same richness of vegetation or longevity as that of the Coal-period proper.

In speaking of any period of the past, especially of one marked by terrestrial conditions, we should carefully guard ourselves against the too common practice of generalizing upon insufficient data.

We have so very few records left to us of the old Land-surfaces, whence all the sediments came which form our stratified rocks, that in studying the latter we are too apt to ignore the source from whence they were derived, and to think of our earth in the past as of a great marine aquarium, full of strange creatures of the sea.

Yet, a moment's reflection tells us that as the forces of heat and attraction have been for ever acting on our earth since it came into being, there must have been land from very remote geologic times; and, further, if conditions in the sea were favourable to the development of abundance of animal life, those on the land were in all probability equally so.

Admitting, however, as we inevitably must, the imperfection of the geological record (especially as regards the preservation of land-surfaces), let us endeavour to ascertain whether there is evidence to show a continuity of terrestrial conditions, and how far we can follow the same as it recedes back from land to land, further and further into the past, until its shadowy shores disappear beneath the pre-Silurian seas, and we reach the last waif washed from its Cambrian coasts.

If we seek for the remains of land-surfaces belonging to the Quaternary period, we shall find them everywhere most abundant and wide-spread, including, as we do under this division, all the latest changes to which our globe has been subjected, and of which primitive man was a passive witness.

It includes changes of level and modifications of coast-lines of enormous extent. In Australia the land has probably undergone great depression, for we find old land-surfaces at a depth of more than 100 feet beneath the present surface (*vide* R. Brough-Smyth's "Gold Fields of Victoria") covered with remains of a vegetation exactly like that now existing, and inhabited by many of the same species of animals, as well as by gigantic Marsupials now quite extinct.

In Northern Africa we have evidences of a great upheaval in Quaternary times, which laid dry the Sahara, and produced a wonderful climatal change in Southern Europe (*vide* Prof. Desor's Paper, "Geol. Mag.," vol i., p. 27, translated by Prof. Ramsay).

In Britain we have abundant evidences of depression and upheaval in late geological times, as witnessed by our Glacial deposits requiring a change of level of 1,500 or 2,000 feet (*vide* "Lyell," Shells on Moel Tryfaen, "Principles," vol. i., p. 195, tenth edition; and "Elements," p. 158, sixth edition).

The coast of Norway, with its raised beaches of recent shells, also attests a change of level of more than 200 feet ("Lyell's Principles," tenth edition, vol. ii., p. 191).

The west coast of Greenland, on the contrary, has been subsiding during the past century for a distance surveyed of more than 600 miles from north to south.

The submerged forests around our own coasts are silent witnesses to the same ceaseless round of change; whilst the evidences derived from their ancient fauna show an equally marked variation in climate and distribution.

Passing from Quaternary to Tertiary times, we have in the deposits of our own island, in France, Germany, Switzerland, Italy, and Greece, abundant evidence both of land-plants and animals, diverging, however, more and more from those which occupy the same regions at the present day.

In this long series of Tertiary and Quaternary deposits, evidences of terrestrial conditions seem present in almost every stratum, and we never lose sight of land, but when the base of the Tertiaries is reached the land-surfaces are divided by greater marine accumulations. Still, freshwater deposits, with land-plants and animals, mark the incoming of the Chalk series in America, and the Maestricht Chalk is found to afford remains of Dinosaurian and Amphibian Reptiles, although these former have yet to be described.*

Leaves of exogenous plants have long been known from the "Quader Sandstein" and the "Planer-kalk," of Germany, beds equivalent in age to the White Chalk and Gault of England.

More recently, in the neighbourhood of Aix-la-Chapelle, beds have been discovered several hundreds of feet in thickness, rich in silicified woods and impressions of leaves, representing more than two hundred species, of which Tree-ferns, Conifers, and Dicotyledonous Angiosperms form the chief part. In the Kentish Chalk itself—a truly marine deposit—evidences exist (in the remains of the gigantic Pterodactyles and the turtle) of the proximity of land. In the Chalk Marl of Folkestone a Dinosaurian allied to *Iguanodon*†

* The specimens referred to are in the collections lately acquired by the British Museum from the Van Breda Museum at Haarlem.

† *Acanthopholis horridus*, Huxley. "Geol. Mag.," 1867. Vol. iv., p. 65. Pl. v.

has also been discovered; and in the Cambridge Greensand the rare remains of birds, besides abundance of Pterodactyles, Cheloniæ, and other Reptilia, evidence littoral conditions.

At the base of the Neocomian series—and included in it by Mr. J. W. Judd*—we come to the great Wealden formation, remarkable for its gigantic Dinosauria, on which so much new light has lately been thrown by Prof. Huxley, Mr. J. W. Hulke, and others.† Here we also meet with entire beds of minute *Cyprides*, whilst the celebrated band of stone in the formation known as Petworth marble, composed entirely of the shells of *Paludinæ*, together with *Unio*, *Cyclas*, *Cyrena*, etc., mark its freshwater origin. The *Lepidotus Mantelli*, a fine Ganoid fish, from the Wealden, with large rhomboidal scales, was probably (like the great Gar-pike of the American rivers) a freshwater fish. Cheloniæ (represented by *Trionyx* and *Emys)* and a Pterodactyle are also found; whilst Coniferæ, Cycadean plants, and Arborescent Ferns, with others of lowlier growth, complete the Wealden landscape.

In the uppermost member of the Oolitic group, we again find, at Purbeck, in Dorsetshire, evidence of a land-surface of the highest interest marked by remains of above ten genera and twenty-five species of MAMMALIA!‡ together with some six or seven genera of freshwater Mollusca—*Cyprides*, Turtles, and Fish, and about forty species of Insects; whilst a large number of small land-Reptilia remain undescribed.

In the Lower Purbeck we also meet with a most interesting geologic relic in the Portland Dirt-bed, with its old vegetable soil and its silicified trunks of Cycadeæ and stools of Coniferæ still preserved *in situ*. We have here also evidences of repeated changes of level, causing alternations of fresh and marine conditions, as shown by the successive beds and their fossil contents.

Passing on to the Kimmeridgian series, we have bituminous shales and impure coal-seams, forming in all a mass of strata several hundred feet in thickness, marked also by the remains of one of the largest Saurians known, the gigantic *Cetiosaurus*, from near Oxford, and by numerous Teleosaurians and other Crocodilian and Gavial-like reptiles. The Solenhofen-stone again reveals an

* See "Quart. Journ. Geol. Soc.," vol. xxvi., 1870, p. 326.

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Oolitic long-tailed bird, the *Archæopteryx*, numberless *Pterodactyles*, both of the long and short-tailed type; together with lacertilian reptiles and countless insects, telling of an Oolitic land rich in Coniferæ and other trees and plants, and swarming with animal existences.

Passing over a series of marine beds, we come again, in the Stonesfield Slate, upon abundance of Insect-life; upon remains of the great *Megalosaurus* and *Pterodactyles;* three genera of Mammalia, and a land-vegetation rich in Ferns, Cycads, and Conifers. Lower still in the Oolitic series, we come to the Plant-beds of Yorkshire, and the Coal-beds of Brora, in Sutherlandshire (also of Oolitic age), rich in Equisetaceæ, Ferns, Zamias, and Coniferæ; and, again, in the Lower Lias of Lyme Regis and elsewhere we have Araucarian trunks and foliage, and another Iguanodon-like Dinosaur (*Scelidosaurus Harrisoni*, Owen), and the remarkable long-tailed Pterodactyle, the *Dimorphodon macronyx;* with Insects' wings and other remains to further attest the continuity of land-conditions.

Descending still, we come to the Rhætic Bone-bed, with its *Microlestes* (*Hypsiprymnopsis*, B. Dawkins) *Rhæticus*, *M. Moorei*, and *M. antiquus*, species of Marsupials, founded upon the evidence of minute detached teeth, discovered in a bone-bed in Somersetshire and at Diegerloch, near Stuttgart; another form, named *Dromatherium sylvestre* by Emmons, occurs in the Chatham Coal-fields. We have also Plant-remains in Triassic rocks, and in Richmond, Virginia, Coal of pure and fine quality, in some places thirty to forty feet in thickness, yielding Coniferæ, Cycadeæ, Calamites, Equisetites, and Ferns. Thin shaly beds divide the Coal, composed almost entirely of the shells of *Estheria*.

In the Trias of Stuttgart, Reptilia are also met with in considerable numbers.

Perhaps one of the most interesting features of this formation is the occurrence of the most extensive beds (not only in this country but in Germany and America) of unfossiliferous sandstone, the surfaces of which are ripple-marked, sun-cracked, and impressed with innumerable foot prints—many of these tridactyle impressions appear to be arranged in bipedal series, like bird-tracks, and others to be those of five-toed, four-footed, flat-footed Labyrinthodont Reptilia. The vast accumulations of salt in certain of these beds probably indicate salt waters in the act of being evaporated down has also been discovered; and in the Cambridge Greensand the rare remains of birds, besides abundance of Pterodactyles, Cheloniæ, and other Reptilia, evidence littoral conditions.

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Here the Secondary rocks end, and we pass on to the Permian or Magnesian Limestone. Again we find land amidst the ocean; for in the Permian of Saxony and Russia as many as sixty species of fossil plants have been obtained, including many Tree-ferns, a great Calamite, a Conifer, and a Lepidodendron.

Still receding further on the Palæozoic seas, we reach the low-lying shores of the Carboniferous epoch, and once again we find in the "Coal Measures" abundant evidence of land-conditions.

Looked at as a whole, the Carboniferous series embraces not only the Coal Measures proper, but also the Millstone Grit and the Mountain Limestone. Sufficient care seems never to have been taken to disassociate (*palæontologically*) this last great formation from the preceding two.

The "Mountain" or "Carboniferous Limestone," is a truly marine formation, devoid of coal-seams (unless we except the Scottish series), and rich in the remains of Corals, Crinoids, Brachiopoda, Conchifera, Gasteropoda, Cephalopoda, and Pteropoda.

In England it attains a thickness of upwards of 15,000 feet, whilst in Ireland its mass is even greater still.

Above the Carboniferous Limestone comes a coarse quartzose sandstone, containing but few fossils, and known as the "Millstone Grit" (from the economic use to which its material is applied). This deposit, often above 1,000 feet in thickness, is not purely of marine origin.

Again, above the Millstone Grit come the Coal Measures proper.

Some idea of their vast geological importance may be formed when we find that in the South Wales Coal-field the strata attain an aggregate thickness of 12,000 feet!

The Coal itself forms only a small proportion of this mass, the main part being made up of intercalated beds of mixed freshwater and marine origin, and comprising layers of shale, sandstone, grit, clay, and ironstone.

Wherever the Coal Measures have been examined, beneath each seam of Coal is found a layer called the "under-clay" or "fire-clay," which forms the floor upon which the Coal itself rests.

* See Prof. Ramsay, F.R.S., "On the Red Rocks of England," etc., "Quart. Journ. Geol. Soc.," 1871, vol. xxvii., p. 189, and p. 241.

Every one of the 100 seams of Coal in the South Wales Coalfield has its under-clay. These Clays, full of roots of plants (called *Stigmaria*) are, in fact, the soils in which the trees and plants grew, which formed by their growth and decay the several layers of Coal.

In many instances the trunks of these old fossil trees have been found standing erect, still attached by their roots to the soil; their decayed and hollow trunks (filled up from above with sediment within) often penetrating through several of the superimposed layers by which the Coal-seam is covered.

Indeed, these aged trees have proved of the highest geological importance, for within their hollow walls have been found a Myriapod, two land-snails (*Pupa vetusta* and *Zonites priscus*), and several species of small Reptilia, which, either intentionally or by accident, had found their way in, but, being unable to escape, they were enveloped in stone, to remain hidden until the energy of Dr. Dawson, of Montreal, should bring them to light.

Coal is, as already stated, the product of the destruction of the continued growth of plants *in situ*. The more perfect the chemical conversion of the tissues of plants into Coal, the less are we able to detect the presence of the organisms which have contributed to its formation. Nevertheless, the "mother-coal" which occurs between the layers of completely-formed Coal, is composed of the broken-up tissues of the plants converted into Anthracite, but still retaining their external forms.

Prof. Morris originally pointed out that the "better-bed-coal" owed its peculiar chemical composition, which gave it its great value for smelting purposes, to the fact that it was composed entirely of a mass of spore-cases, which Mr. Carruthers has shown to belong to a Lepidodendroid genus called *Flemingites* (see "Geol. Mag.," 1865, vol. ii., pl. xii., p. 433), and (as he informs me) to *Sigillaria*, and other allied forms. Prof. Huxley subsequently made the interesting observation, from specimens prepared with singular care and skill by Mr. Newton, that these spore-cases were buried in the shed spores themselves, and both together make up the substance of this most remarkable deposit of Coal. But in readily accepting this interesting discovery, let us guard ourselves against the tendency of all modern scientific generalizers who take up ideas as soon as issued from the mental mint, "and run into extremes;" for, admitting that a giant Lycopod forest in the Coal-period would, *in the course of years*, probably shed several times its actual tree-and-branch-bulk of seed-spores, yet it most probably shed its leaves as well as its spores and its wood-growth, and that of the forests of giant *Calamites* and ferns around would amount to an enormous mass in the course of ages of accumulated growth and decay, such as the Coal-forests reveal to us. The tiny acicular leaves of a pine-forest of to-day often form a mass several feet in thickness beneath and around the parent trees, which needs but the proper accessory circumstances to convert it into Quaternary Coal.

Of the three hundred plants which occur in the Coal-period, we know but little, whilst a great part of the vegetation has probably left no sign. For experiments made long ago by Dr. Lindley go far to prove that most vegetable tissues break up with great readiness and become completely disorganized when saturated under water. Thus he found that after two years' submersion beneath freshwater, 121 out of 177 species of plants had entirely disappeared; and of the fifty-six remaining, the most perfect were *Coniferæ*, Palms, Ferns, and *Lycopodiaceæ*. There are probably no palms in the Coal Measures, but remains of the other three classes are most abundantly preserved, which lends strong confirmation to Dr. Lindley's experiment.

Formerly, it was supposed necessary, in order to account for the rich deposits of carbonised vegetable remains in the Coal, to assume a tropical temperature with a damp humid atmosphere, composed in great part of carbonic acid gas.

Indeed, surprising as it may seem, so lately as May, 1869, this doctrine was advocated by an eminent chemist, Dr. T. Sterry Hunt, F.R.S., in a lecture delivered before the Royal Institution (see Report, "Geol. Mag.," vol. iv., pp. 357-369). He there stated—"With regard to the composition of this earlier atmosphere—unfitted as it was for the higher forms of life, still from the comparatively large amount of carbonic acid present, it would seem to have been peculiarly fitted for the development of luxuriant vegetation; and it was long since pointed out by Brongniart that we might suppose a marvellous luxuriance of vegetation in earlier periods of the earth which gave rise to enormous beds of coal and other fossil fuel; for we should judge that this abundance of carbonic acid favoured a wonderful development of vegetation, and at the same time the elimination of the carbon in the shape of coal would help powerfully to purify the air at that time."* He further suggests that this dense canopy of carbonic acid gas "would permit the solar heat to pass through our atmosphere, but would prevent its escape by radiation after it had once heated the surface of the earth, and would thus immensely augment the temperature of the lower strata of the atmosphere, producing an effect precisely as if we had covered the whole earth with an immense dome of glass—had transformed it into a great orchard-house—and had thus established from the equator to the poles, a moist, warm, equable climate, which would permit even within the limits of the polar circle a luxuriant vegetation."†

However ready we might be to accept Prof. Sterry Hunt's dictum —if applied to *pre-Carboniferous vegetation*, about which we know so little—we cannot, with our present knowledge of the Coal-period, and the requirements both of its animal and vegetable life, accept his views, or admit them to be tenable, having regard to the known fauna and flora of that epoch.

Furthermore, the fact that precisely similar deposits are found to occur in arctic as well as temperate and subtropical regions, does not seem to us to prove "a moist, warm, equable climate established from the equator to the poles," but rather proves that at particular periods *parts* of the earth were *then, as now*, favoured with special advantages, as regards climate, over other parts in the same degree of latitude; because, *then, as now*, the isothermal lines were (owing to local circumstances of coast-lines, winds, and currents) deflected from a straight course.

Thus, as I have elsewhere pointed out (see "Geol. Mag.," 1868, vol. v., pp. 297-303), at the present day, in the month of July, huge icebergs may be seen off the east coast of N. America, *in the same latitude* as London, with an atmospheric temperature of only 48° ! Whilst the harbour of St. John's, Newfoundland, 2° further south than Liverpool, has been blocked up with ice as late as the month of June !

Surely if the small portion of the Gulf-stream which we enjoy can effect such a deflection in the isothermal line as these two facts indicate, what might it not be able to achieve under a different

* Later experiments have, however, proved that plants, like animals, are at once *poisoned* by an excess of carbonic acid.

† Chemical investigation shows that at the present day there is probably as much or more carbonic acid in the atmosphere in a free state as in the whole mass already fixed as carbon by plants and animals on the surface, and by all the coal-seams put together.

arrangement of land, by which its whole volume might be made to pass in a northerly direction? For we know that Greenland bears testimony to *two* fossil floras—one in the Tertiary and one in the Carboniferous period—and it seems highly improbable that an "envelope of carbonic acid gas" was—*if it ever existed*—present at so late a period as the Miocene Tertiary. If, then, this later flora flourished in this exceptionally high arctic latitude, favoured by the varying eccentricity of the earth's orbit, aided by the warm currents from the equator, why should not the recurrence of such conditions, at an earlier period, have sufficed to favour the production of the older coal-beds?

Not for a moment questioning the proposition that in the earlier ages of our globe, its condition was very different both *terrestrially* and *atmospherically too* (if chemists please) than at the present day; nor, that cataclysmic action has effected many important changes in the configuration of land-surfaces in past geological time; yet by far the greatest part of the work performed in Nature's laboratory must be attributed to those humble yet untiring agents —upheaval and denudation, sunshine and shower, snow and ice, heat and cold, ebb and flow, which have never rested night nor day through all the ages of time since the waters were gathered together into one place and the dry land appeared.

But to return to our subject. Had the Coal been accumulated under exceptional conditions of light, heat, and atmosphere, it would be absolutely necessary to exclude animal life from the scene of its formation.

Such, however, was not the case, for in the progress of geological discovery we have become acquainted with no fewer than 30 species of land-dwelling, or amphibian reptiles, 150 fishes, more than 12 species of insects, two myriapods, two scorpions, a *Eurypterus*, six species of king-crabs, a host of Entomostraca, one, or more, macrouran decapods, two land-snails, besides *Unionidæ* and a host of other Mollusca.

There are evidences of sunshine in the flowering organs,* called *Antholithes*, and in the ripened fruits and seeds; of shower in the impressions of raindrops on the mud; of tides in the ripple-marked sandstones, covered also with the impress of the feet of the reptilia, which must have swarmed along the Carboniferous shores and rivers.

* Indeed, no *green* leaf can be formed without sunlight, for the Chlorophyll is not developed in plants living in the dark or shade.

Nor were these wooded shores destitute of melody, for albeit, no bird (so far as we yet know) built its nest there, the familiar chirp of the cricket was already to be heard, whilst the hum of the many winged insects enlivened the solitudes of these strange old forests.

We have referred to the numerous beds of Coal occurring in the South Wales Coal-field, but in the cliffs of the South Joggins in Nova Scotia the total thickness of Coal strata is not less than 14,570 feet. In a space of 1,400 feet Dr. Dawson noted no fewer than sixty-eight root-bearing soils; and erect trunks have been observed at seventeen different levels. (See Dr. Dawson's "Acadian Geology.")

The Coal-strata here, it should be observed, are exposed in a long sea-cliff, and are tilted up at an angle of 24°; but the trees stand at right angles to the "dirt-bed" or soil in which they grew.

Various are the hypotheses which have been offered in explanation of the accumulation of the successive beds of the Coal in horizontal superposition. The most plausible hitherto propounded are:—

(1st). Coal was accumulated in the wide alluvial plains and deltas of great rivers, such as the Amazons, the Mississippi, the Ganges, or the Yangtse-Kiang. In the Mississippi, four or more buried forests have been observed superimposed one upon another with their underclays or root-beds and the erect Cypress-trees buried in drift and mud.

(2nd). The Mangrove swamps along tropical insular coasts. In the former case the layers of vegetation are covered by freshwater mud, with the organisms living in, and common to, a great river. In the latter case the vegetable growth is covered up by marine silt, sea-shells, &c.

One difficulty, however, not met by these illustrations, and requiring to be explained in order to clear up the origin of coal, is its *exceeding purity* and *freedom from* admixture of foreign matter; each coal-seam being, so to say, *completed* and then *sealed up*, so that its hydro-carbons should all be retained in the best possible condition for fuel. This could not have taken place in a mere cypress-swamp or mangrove-swamp, such as one sees in Tropical America at the present day.

If, however, you picture a vast alluvial plain covered with a Cryptogamic forest of giant Lepidodendra and Sigillaria growing on a stiff tenacious clay soil, capable of retaining the rain-fall, then you have the conditions suited for the rapid accumulation of peat, and that is the purest form we know of any great accumulation of vegetable matter *unmixed* with foreign material, which is the peculiar feature of the Coal Measures.

If any stronger argument than we have used against claiming for the Coal-period special and abnormal conditions were needed, it is to be found in the fact that we have Coal of Tertiary and Secondary age as well as of Primary or Palæozoic.

The Tertiary Brown Coal of Germany and Russia, the Bovey-Tracey Lignites, the Miocene Coal of the Mackenzie River, North America; the Kimmeridge Coal; the Brora Coal (Oolitic in age); and, indeed, judging by the plant-remains, there is good reason for believing the Coal of China to be of Secondary age; the accumulated growth of plants such as Cycads, Taxineæ, Araucarians, Equisetaceæ, and Ferns, corresponding in character with those found in the Oolitic plant-beds near Scarborough, Yorkshire.

Again, there is reason to believe that some coal may be of Devonian age, for Dr. Dawson has already made known a land-flora and fauna of Devonian times, agreeing somewhat with the plants which form the true coal,

Lastly, Lycopodiaceous seeds occur in the Upper Silurian, and lower still, we get graphites, which may owe their origin (as the oil-bearing strata of pre-Carboniferous age no doubt did) to the destructive distillation of old Silurian Coal-beds, the products of old land-surfaces, distilled in Nature's own retort.

EXCURSION TO OXFORD, MAY 12TH AND 13TH, 1871.

Directors—Professor PHILLIPS, M.A., Hon. D.C.L., Oxon, F.R.S., &c., and J. P. EARWAKER, Esq.

The Members, at the head of whom were the President, the Rev. Thomas Wiltshire, M.A., F.G.S., &c., and Professor Morris, F.G.S., H.M.G.A., assembled at the beautiful new University Museum, and were received by Professor Phillips, who described the Museum, its arrangement and contents, in a most interesting and instructive lecture while conducting the visitors through the spacious halls of this noble memorial of Oxford's regard for Science.

There is a peculiar double arrangement of the Palæontological Collection by which the student may, with equal ease, make himself acquainted with the organisms derived from any one geological formation, or devote himself to the study of the fossil remains of a single class or order of the animal or vegetable kingdom. The Museum is not crowded, but contains good specimens of those species which are most typical or characteristic. Here, too, with the fossil remains of Saurians and Mammals, are the complete skeletons of analogous living genera, an arrangement most advantageous to the student. The unique collection of the remains of *Cetiosaurus* adds greatly to the value of the Oxford University Museum. A graphic description of the enormous bones of this genus was given by Professor Phillips, who, by a comparison with corresponding crocodilian bones, impressed his hearers with the vast size to which these huge creatures attained. The estimate made by the Professor was that the Cetiosaurus was fifty feet long and twelve feet in height, the femur being fully sixty four inches long, while the femur of a crocodile, nine feet long, with which it was contrasted, was no more than nine inches in length.

In the afternoon the party proceeded to Shotover Hill, examining by the way the excavations in the Oxford Clay near the City, and the exposures of the Coral Rag and the Kimmeridge Clay on the side of the hill. Near the top of Shotover, Portland Sands and a thin band of Portland Stone are seen, and above these beds, and forming the summit of the hill, are the "Iron Sands," which have been the subject of much dispute. These highly ferruginous beds were considered to be Lower Greensand, but the finding of a considerable number of fresh-water species of Mollusca without any marine exuviæ, has induced Professor Phillips to believe the "Iron Sands" to be of Wealden age. From these sands at the summit of the hill ochre has been obtained in large quantities.

In the evening the members were entertained at dinner by James Parker, Esq., F.G.S., who afterwards gave a *soirée*, and exhibited his very valuable collection of Reptilian Remains and other fossils from the neighbourhood of Oxford. These were described by Professors Phillips and Morris, and afforded great gratification to the visitors.

On the second day an early visit was paid to Merton College for the purpose of enabling the members to inspect the large collection of fossils which Mr. Earwaker, of that College, has brought together.

Subsequently the party started by carriage for Islip, Enslow Bridge, and Kidlington. At Islip, a fine section of the Forest Marble and Cornbrash with the usual fossils of these formations, is exposed; and an Ammonite, probably the first from the Cornbrash of this district, was found. The village of Islip is, however, interesting to geologists on other grounds, for here lies Buckland. Around the tomb of the great geologist, with his distinguished successor at their head, the party assembled. The memorial is of polished Aberdeen granite, and the inscription briefly records the fact that there lie the remains of Dr. Buckland, Rector of Islip, Dean of Westminster, and first Reader in Geology in the University of Oxford.

The quarries at Enslow Bridge, which have yielded a large number of the Saurian bones now in the University Museum, was then visited, and here the Members were highly gratified to find that during the morning a very fine skeleton of *Teleosaurus* had been found, and the head, taken out of the bed in which it had lain for untold ages, was exposed to view. This quarry is in the Great Oolite, the lower and uppermost strata of which in Oxfordshire yield remains of *Megalosaurus*, while in the middle beds we find *Teleosaurus*. A very remarkable bed of about twelve inches thick occurs a little above the *Teleosaurian* zone, crowded with *Terebratula maxillata* to the exclusion of every other species.

Several other sections of the Great Oolite, Forest Marble, and Cornbrash were examined, and the weather being very fine the drive through the beautiful country was much enjoyed, and the return to Oxford effected in time to allow of the Members taking their departure for London by the evening train.

An extended Report of an Excursion to Oxford in 1869, by JAMES THORNE, *Esq.*, has been published by the Association.

EXCURSION TO GRAYS, ESSEX, May 20th, 1871.

Director—The President, the Rev. T. Wiltshire, M.A., F.G.S.

(Report by M. Hawkins Johnson, Esq., F.G.S.)

The ride from Fenchurch Street to Grays by rail, is not, to a geological eye, the dreary flat it may appear to many. The mind reverts at once to the time when the Romans had not yet built the river wall, which for so many ages has protected the marshes from daily overflow, when peaty swamps, muddy pools overgrown with reeds, and long tracts of shingly gravel, were by slight variations in the level of the land sometimes a few inches above, and sometimes a few inches below the waters of the estuary, which then rendered useless thousands of acres, now becoming by cultivation, and the judicious application of London sewage, some of the most valuable grass lands. This embankment of the river in early times, considering the difficulties of the undertaking, and the magnitude of the results, is undoubtedly the most wonderful work ever done in this district by the hand of man.

The curious mass of Chalk at Purfleet, standing up in isolation, with its cap of Thanet Sand, looking like the remnant of some old castle, and the cliffs exhibiting a similar section at Greenhithe, on the other side of the river, both furnished interesting subjects of conversation, so much so that but a few minutes seemed to have elapsed when the train stopped at Grays station.

The party now proceeded at once to Mr. Meeson's chalk-pit, a very extensive excavation, exhibiting a beautiful section of the Upper Chalk, capped by the Thanet Sands, overlying which is the gravelly Brick-earth deposit of Post-Glacial age. The President now gave a brief address to the Members assembled, in which he pointed out the leading features of interest, and the party then scattered themselves over the quarry to make personal acquaintance with the details of the surface exposed.

The Chalk here contains beds of nodular flints, distributed with such regularity, that in section they show out as long, black, broken lines; also flint nodules irregularly scattered throughout the mass. Sheets of tabular flint were seen parallel to the lines of stratification; also some sheets of tabular flint cutting the lines of stratification obliquely; these latter mostly present the appearance of being double, that is, composed of two layers, and are well worth careful attention, as their origin is difficult to account for. The green-coated flints, known as the "Bull Head Bed," were well seen in their usual position, between the Chalk and Thanet Sands, also many flint casts of echinoderms, in a good state of preservation.

The fossils obtained from the Chalk were, a large fish in very bad condition, not identified; teeth of *Otodus appendiculatus*, and *Ptychodus;* shells of *Plagiostoma spinosa*, *Cytherea* and *Inoceramus; Terebratula carnea; Diadema*, also separated plates of the same, called by the quarrymen "nipple rings," from the projecting processes for articulation with the spines, which were also found; the other common echinoderms were tolerably plentiful, such as *Ananchytes ovatus*, *Micraster cor-anguinum*, and *Galerites albogalerus;* the coral *Parasmilia* and several Bryozoa were also noted.

Large masses of Chalk flint, coloured brown by oxide of iron, were found above the Bull Head Bed, indicating a great amount of denudation of the Chalk before the deposition of the superincumbent sand, and representing probably a great interval of time; a mass of Sarsen-stone was also seen, no doubt an indurated portion of a sandy bed in the Woolwich Series, which originally extended over this area, and whose *débris remanié* constitute in all probability a great portion of the brick-earth bed at the top of this section.

The junction of the Chalk with the superincumbent layers is full of interest, and suggested innumerable speculations to account for the peculiar contortions of outline presented. Generally the irregular portions of chalk above a certain line appear to be *remanié*, and contain rolled pebbles and clay mixed with the mass. A bed of pebbles in the gravel bed where it passes over a portion of the Chalk, in which there is one of those funnel-shaped excavations filled with sand, known as "sandpipes," is much bent downwards at this point; it has, in fact, sunk in, showing that the formation of the sand pipe took place long after the deposition of the beds above, which of course were originally level, or nearly so.

Attention was now directed to the Brick-earth beds, a little lower down the river, and known as Pearson's pits. The bed where the Mammalian remains were discovered is in that part entirely removed, and the surface planted with potatoes, but low down in the section exposed, two or three thin sandy beds intercalated with marly clay were found, abounding in freshwater shells, the most abundant being *Cyrena fluminalis*, a shell now extinct in this country, but still found living in the Nile, a fact which indubitably points to the existence of a warmer climate at the time of the deposition of these beds than we have now. *Bithynia tentaculata*, *Valvata piscinalis*, and other recent shells were also found; and in another bed, about three feet higher in the series, *Unio littoralis* abounded; this shell is also extinct in this country, but is found living in the Loire at the present day; and as this latter bed is more recent than the Cyrena beds, and its shells do not require so warm a climate, the alteration of the temperature may probably have gone on gradually in the same direction from the earlier epoch to the present day.

The false-bedding of the sands in this pit is well worthy of observation, and when the party separated, the general opinion seemed to be that it would be very desirable to pay another visit to the spot, and to give many of the points of interest a still more careful examination.

EXCURSION TO THE YEOVIL DISTRICT, May 29th, 30th, 31st, and June 1st, 1871.

Directors—Professor Buckman, F.G.S., F.L.S., &c., and J. Logan Lobley, Esq., F.G.S.

(Report by Mr. Lobley.)

The Excursion to Yeovil and the surrounding district was arranged for the purpose of enabling the Members to inspect the Lower Jurassic formations of Somersetshire and Dorsetshire, to study the fossils they so abundantly yield, and especially to examine the evidence of the correlation of certain strata with members of the Gloucestershire Oolites which may be their equivalents.

The Yeovil Junction section of the beds of yellow micaceous sand, which are considered by some geologists to be a portion of the Upper Lias and by others to belong to the Inferior Oolite, was seen immediately the party alighted from the train. The Sands are here exposed to a depth of sixty or seventy feet, and are capped at a few yards from the side of the railway cutting by beds of undoubted Inferior Oolite, containing the usual species of this formation in abundance, including *Rhynchonella spinosa*, *Terebratula Phillipsii*, *Lima proboscidea*, &c.

Leaving the section at Yeovil Junction, the party proceeded by a pretty country road to the village of Closworth, passing over the

Fuller's Earth and the Cornbrash, and reaching the Forest Marble on arriving at the village. At the charmingly situated Rectory luncheon was provided by the Rector, the Rev. E. Bower, M.A., one of the oldest members of the Geologists' Association. The inspection of the large collection of Mesozoic fossils, containing many exceedingly fine specimens, which Mr. Bower has during fifty years brought together, occupied several hours most instructively. It is worthy of remark that the Rev. Mr. Bower has shown his appreciation of the interesting character of the geology of the neighbourhood in which he resides, not only by collecting, with persevering care, the fossils of the locality, but also by the employment of the Forest Marble of his parish as an ornamental stone in the restoration of Closworth church. After leaving Closworth the road to the town of Yeovil was taken, and several road sections of the Fuller's Earth and the yellow or, more correctly, buff-coloured Sands of the district were observed.

The Members dined together, and subsequently inspected the collection of the fossils of the neighbourhood of Yeovil in the possession of Mr. T. C. Maggs of that town. This collection, though not as yet large, contains very fine specimens, and is preserved with a care which it is most gratifying to see bestowed by a gentleman so favourably situated as is Mr. Maggs for forming a typical, and in a certain sense, exhaustive, collection of the species of the rich fauna contained in the rocks of the district.

Early on the second day, the fine escarpment of Babylon Hill, which bounds at this place the valley of the Yeo, was ascended under the guidance of Professor Buckman, by a road cut through the Sands. This section of the Sands is an extremely fine one, exposing the beds to a depth of one hundred and fifty feet. Bands of concretionary limestone, sometimes continuous for long distances, but more frequently intermittent, project from the surface of the cliff. The fertile and beautiful valley of the Yeo is well seen from the escarpment, and the course of the river towards the sea can be traced for many miles. Professor Buckman here pointed out the phisiography of the country south of the Mendips, and afterwards led the way to a section of fossiliferous Inferior Oolite overlying the Sands. The party then proceeded along the road to Sherborne, as far as the celebrated Half-way House quarries. The "Cephalopoda Bed" here exposed was examined, and many fossils were obtained from the two exposures of the Oolite which have been for many years *prolific of* organic remains.

Entering the county of Dorset, and continuing along the road to Sherborne, that town was reached after a walk of about two miles over the Inferior Oolite. Near the town are extensive quarries, and these afford fine exposures of the Inferior Oolite, which is at this place a light-coloured, compact freestone, and used for building purposes. Fossils are abundant, especially Cephalopoda and Brachiopoda. *Ammonites Humphresianus* and *A. Blagdeni*, with Nautili and Belemnites of large size, and in a fine state of preservation, are numerous, and Terebratulæ are very common. Some time was accordingly spent in collecting, after which the Members proceeded by rail to Bradford Abbas, at which village is situated the residence of Professor Buckman. Here a fine opportunity was afforded for the study of the "Cephalopoda Bed." The Professor conducted his visitors to a small quarry on his farm, where a quarryman with a pick exhumed, in a few minutes, great numbers of fine Ammonites. This little quarry is, indeed, remarkable, since it has yielded a very large number of species which have been of great value in the determination of the geological position of the "Cephalopoda Bed."

Professor Buckman entertained the party at dinner, and afterwards expounded his views on the geology of the district, with especial reference to the position of the Sands and the "Cephalopoda Bed."

The concretionary masses of the Sands, it was stated, contained fossils essentially Oolitic and not Liassic, and the evidence appears to Professor Buckman overwhelmingly in favour of these sands being of post-Liassic age, and belonging properly to the Inferior Oolite series. It remains, however, to be shown to what portion of the Inferior Oolite they belong, whether to the Lower, the Middle, or the Upper division; whether they are the equivalent of the Sands of Gloucestershire, as seen at Nailsworth and Frocester Hill, of the "Pea Grit" and "Fimbria-beds," or of the "Gryphite Grit" and uppermost beds of the Gloucestershire Oolites. In this place it can only be said that Mr. Charles Moore correlates the Sands in the neighbourhood of Yeovil with those at the base of the Inferior Oolite in Gloucestershire, while Professor Buckman considers them to be the equivalents of the Middle and of a portion of the Upper division of the Inferior Oolites of Gloucestershire, and the "Cephalopoda Bed" of this district to be at the top instead of at the base of the formation, as has been hitherto supposed.

On the following day, after an inspection of a collection of Jurassic fossils belonging to Mr. Henry Monk, of Yeovil, the far-famed quarries of Ham Hill were visited, and the great bed of Inferior Oolite freestone, which has supplied material for the churches and other buildings of the district for centuries, was carefully examined. This remarkable bed is chiefly composed of comminuted shells aglutinated together with carbonate of lime and peroxide of iron; but, strange to say, not a fragment of a shell has been obtained from this vast deposit of sufficient size for the species to be determined. Ham Hill rises steeply from the surrounding country on three sides, and the commanding character of the eminence appears to have been early recognised, since the remains of a very ancient camp, probably Roman, are to be found on the summit. Leaving the breezy hill behind, the party rapidly traversed the rich vale to the west, and in a short time arrived at the little town or village of South Petherton, made well known to geologists by Mr. Charles Moore, who has obtained from this locality a rich and interesting fauna. South Petherton stands on the Lias which is here quarried for lime-burning, and the sections thus produced show the Middle Lias or Marlstone, with a thin capping of Upper Lias. The Marlstone is very fossiliferous, yielding Cephalopoda, especially Belemnites, most abundantly. Brachiopoda are also numerous. *Spiriferina rostrata*, *Rhynchonella acuta*, and *R. tetraëdra* being perhaps the most common. In the Upper Lias, Mr. C. Moore found several species of *Leptæna*, a genus previously considered to be exclusively Palæozoic.

On the return to Yeovil several sections of the Middle Lias were seen. The Marlstone on which Yeovil stands, and which underlies the yellow Sands forming the hills around the town, is quarried for inferior building stone. It is very hard and tough, and contains many fossils, amongst which may be specially noted as being conspicuous on account both of size and abundance, *Pinna Hartmannii* and *Pecten æquivalvis*.

The fourth day was devoted to an examination of the fine coast section extending eastwards from Seaton in Devonshire. The Keuper Marls are here seen forming richly coloured picturesque cliffs of a hundred feet in height, which stretch along the shore from the mouth of the Axe for upwards of a mile, when Liassic strata begin to appear and afterwards form, with a capping of Upper Greensand, the cliff, until the famous landslip is reached. Enormous blocks of chert, precipitated from the Upper Greensand at the top of the cliffs, lie at their base, and abounding, as they do, with sponge spiculæ, are objects of great interest. The party returned to London in the evening.

ORDINARY MEETING, June 2nd, 1871.

The Rev. Thomas Wiltshire, M.A., F.G.S., &c., President, in the Chair.

The following Donations were announced :—

"The Quarterly Journal of the Geological Society," from that Society.

"Abstract of the Proceedings of the Geological Society," from that Society.

"Report of the Chief Commissioner of Mines for the Province of Nova Scotia, for the year 1870," from the Office of Mines, Nova Scotia.

"Journal of the London Institution," from that Institution.

Cuvier's "Essay on the Theory of the Earth," from Ernest Swain, Esq.

Ure's "Geology," from Ernest Swain, Esq.

"Introduction to Geology," by Robert Bakewell, from Ernest Swain, Esq.

"On a specimen of Diplograpsus pristis, with Reproductive Capsules," by John Hopkinson, F.G.S., F.R.M.S., from the Author.

"On the Post-Glacial Deposits of Western Lancashire and Cheshire," by C. E. De Rance, F.G.S., from the Author.

The following were elected Members of the Association :—

Robert Clark, Esq., F.R.G.S.; The Rev. Osmond Fisher, M.A., F.G.S., &c.; John Foulerton, Esq., M.D., F.R.S.E.; Roger Gaskill, Esq., B.A.; John Haines, Esq., F.G.S.; Marshall Hall, Esq., J.P., F.G.S., F.C.S., F.R.M.S.; Charles Johnson, Esq.; Thomas Charles Maggs, Esq.; and Henry Walker, Esq.

The following Paper was read :—

On Flint.

By M. Hawkins Johnson, Esq., F.G.S.

The following remarks on the formation of flints have been put together principally with a view to provoking a full discussion of the subject. It is one in which I feel much interested on account of the obscurity in which it appears to be involved, and I am consequently glad of the opportunity of bringing it before the Association.

I propose first of all to allude to what everybody may see for himself if he looks; secondly, to parade a few facts which I judge to be relevant; thirdly, to draw the inference.

I suppose our first acquaintance with flints may generally be traced to juvenile examinations of the pebbles in gravel walks, in the beds of streams, and on the beach at watering places; and it does not require very much power of observation to find out that in all these cases the original form of the stones has been considerably altered; those in the rivers, and in some gravels, which we may suppose to have had a similar origin, having been split and their corners and edges slightly rounded off by the action of the weather and of gently running water; while those on the sea beach and in other beds of gravel have a very different appearance, characterised by decided rotundity, the result of many and hard knocks from their fellows on the shore of some stormy sea.

There is a little inference, which, as it accounts for the fact, must be held to be reasonable, which is very readily drawn from the great preponderance of siliceous pebbles on sea beaches generally, although the detritus of rocks of a different chemical nature must have been mixed with them from time to time, and probably in larger quantities; it is, that siliceous substances are much harder than these other substances, and comparatively insoluble. Another look at these rounded stones will show, however, that there is probably a considerable difference in respect of solubility, and therefore, also a difference either in physical constitution or chemical composition between flints and quartz, quartzite, &c., for on cracking them open we often find the *flints* with several concentric bands of different colours extending sometimes more than a quarter of an inch into the mass, and following, not the original form of the flint, but its present rounded outline, showing that these coloured bands, due either to chemical change or infiltration, are, in comparison with the age of the stone, matters of but recent date—the result, in fact, of atmospheric and aqueous influences; while the *quartz* pebbles, although subjected to the same agencies, and as chemists tell us, made of the same material, do not appear to have suffered the slightest alteration. Sometimes the flints appear to have been changed in colour, and even in structure, by these agents throughout the whole mass. Rounded and shingle worn, they were subsequently united by a siliceous cement, and in that state constitute the "pudding-stones," with which we are all familiar. The nature of this cement is not very intimately connected with our present subject.

There are beds of rolled flints generally found at the base of the London Clay, and at the base of the Woolwich Beds; and another very remarkable thin bed of green-coated flints, not rolled, and known *as* the "Bull Head Bed," is generally seen on the top of the Chalk *underlying* the Thanet Sands.

I may here allude to the occasional occurrence of silicified wood and siliceous casts of shells in the Thanet Sands, as I think they will be found to be as good flint, chemically and physically, as any of the others I have mentioned.

Other accumulations of flints may often be seen in large quantities upon or near Chalk subsoils; the stones ragged and split, with a rough, almost worm-eaten appearance. They are mostly white or buff-coated outside, and grey or black in the interior, and not waterworn to any appreciable extent. These accumulations are, no doubt, to be attributed to the quiet washing away of the chalk matrix, in which they were originally imbedded, by pluvial action, the flints being left by virtue of their gravity and insolubility.

We next see the flints in Chalk pits and cuttings, where they form a very striking feature by their occurrence in beds of separate nodules, continuous over large areas, and showing in section black broken lines parallel to the stratification. There are other beds of flint in the Chalk, however, which are not nodular, but in which the flint forms a continuous tabular sheet, generally parallel to the lines of stratification of the Chalk, but in some cases running obliquely across those lines. There is a vein of this sort in a chalk pit at Woburn, near Marlow; there are also some in the pits at Grays. Flint nodules also occur in the Chalk in another manner, namely, as "pot stones" or *paramoudræ*, in which case they are piled up vertically, one above another. There are three specimens of this particular variety, brought from the neighbourhood of Norwich, on the staircase of the Geological Society's rooms, in Somerset House.

Going deeper and deeper, we next come to the chert beds and nodules in the Upper Greensand, and the same again in the Lower Greensand. Although chert is not generally considered to be identical with flint, yet the two are really so much alike, that as I deem them to have had a similar origin, I have not hesitated to include them both under the same head. Perhaps the most striking differences superficially are these—flints have generally a much better defined boundary than chert, which often seems to merge gradually into the surrounding mass, and as a rule, flints are more translucent and have a cleaner fracture. The Purbeck Beds in the neighbourhood of Swanage and elsewhere abound in nodules and layers of chert, in which are imbedded organic remains of the same description as those that are found in the surrounding limestone beds, namely, freshwater shells, *Cyprides*, &c.

In the "Dirt-bed" of the Isle of Portland we have a whole forest of trees that have been converted into flint; while below it, and on the top of one of the limestone beds in the same district, we have again a layer of nodular flints, and in the lower beds, just above the Kimmeridge Clay, there are both nodules and veins of flint and chert. The Kimmeridge Clay itself contains the silicified bones of saurians.*

The Coal Measure sandstones, and the Mountain Limestone also, both contain chert; in the latter often banded with darker lines parallel to the stratification; and I have heard of flints occurring even in slate rocks, but I have never seen them.

I am told that flints have not yet been discovered in the unaltered gravels and sedimentary rocks of Cambrian and Silurian age; but that, of course, is no proof that they do not exist, and for my own part, I can see no reason, *à priori*, why they should not be found, even in the most ancient sedimentary deposits, so long as they remain unaltered; the very existence of the gravels is in itself a proof that similar agents were at work then, producing effects similar to those we know to have been produced in ages long subsequent to them, and which are still being produced in our own days.

If we now proceed to examine these flinty substances a little more closely, and crack a few of them open, we shall find that they are none of them destitute of interest; for, besides the conchoidal fracture, which is in itself a marvellous phenomenon, the naked eye alone often shows us imbedded in them the remains of shells, corals, echinoderms, sponges, &c., and cavities lined with glittering crystals of quartz or other minerals, or filled with banded agates; while the microscope introduces us into a perfect treasury of objects for investigation, such as Foraminifera, *Xanthidia*, *Pyxidiculæ*, sponge spicules, and fragments of numerous other organic structures, imbedded in what is in itself by no means a homogeneous matrix. In the hollow cavities of some, as in one of the specimens on the table, sponge spicules may even be seen with the unassisted eye, projecting like bristles from the inner surface; and in the lumps of chert taken out of blocks of Portland Stone, triradiate spicules may readily be detected, standing in relief on the surface of the mass, if not with the naked eye, at all events with a pocket lens of moderate power. In other cases the cavity contains a siliceous core, often exhibiting the structure of sponge tissue, or a loose siliceous powder abounding in sponge spiculæ and Foraminifera. The white external crust on the flints in the Chalk is not, as I find many persons have supposed, a

* *Specimens* from Radley, Berks, may be seen at the Museum, in Jermyn Street.

mere coating of whitewash—part of the chalk matrix, in fact—but is as perfectly siliceous as the mass of the flint; it is quite insoluble, even when boiled for a long time in nitric acid, and its colour is due solely to its physical structure, the siliceous substance being here in a more open or porous condition.

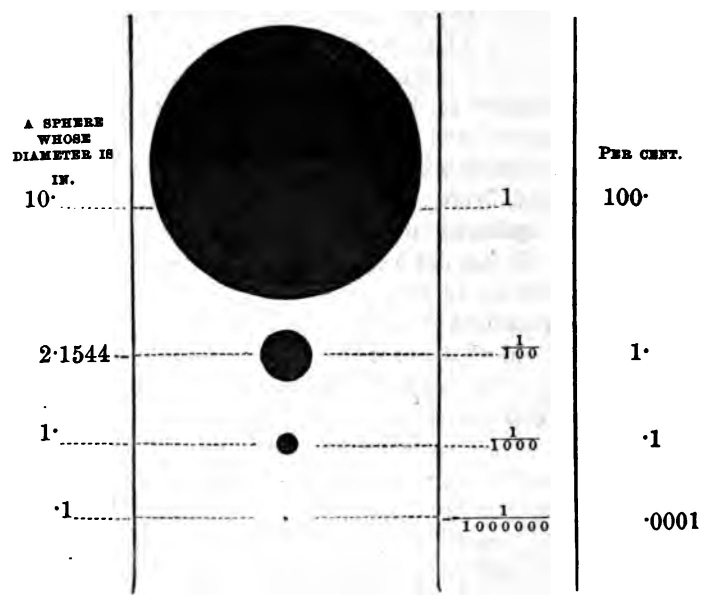
A careful examination of flints that have been quietly acted upon by the weather without being subjected to rolling, will also show that their solid substance is not homogeneous, and that the atmospheric agents differentiate the component parts in a very definite way; some showing, as it were, an almost membranous surface, below which is a looser structure, permeated by canals, which in many cases are filled with chalcedony, and stand out in relief like branching threads or stems; these canals may also be seen occasionally on surfaces produced by fractures comparatively recent, where the weather has rendered them visible, by bringing them out in a different colour to the remainder of the mass. In other cases, where a recent fracture shows only cloudy brown markings in the flint, the weathered surface shows the brown cloud clearly resolved into a reticulate structure, that points most strongly to an organic origin.

Of the relevant facts to which I wish to call your attention, the first is the striking analogy that exists between the elementary substances, Silicon and Carbon. Each has three distinct allotropic conditions; namely, crystallized, graphitoid, and amorphous. Silicon crystallizes in regular octahedra, with curved faces; the diamond also, which is crystallized carbon, has the same form. Both are tetrads; silicon combines with four equivalents of hydrogen to form gaseous silicetted hydrogen; while carbon combines with four equivalents of hydrogen to form light carbonetted hydrogen, or marsh gas. Both combine with oxygen in the same proportions, with two equivalents of which silicon forms silicic anhydride or silica, while carbon, with the same number of equivalents of oxygen, forms carbonic anhydride, or carbonic acid; from these two substances are derived the analogous series of silicates and carbonates. Then we have bisulphide of silicon analogous to the bisulphide of carbon, and a tetrachloride of silicon, a highly volatile liquid, corresponding to the tetrachloride of carbon.

Si	Silicon.	C	Carbon.
$Si\,H_4$	Silicetted Hydrogen.	$C\,H_4$	Marsh Gas.
$Si\,Cl_4$	Tetrachloride of Silicon.	$C\,Cl_4$	Tetrachloride of Carbon.
$Si\,O_2$	Silica.	$C\,O_2$	Carbonic Acid.
$Si\,S_2$	Bisulphide of Silicon.	$C\,S_2$	Bisulphide of Carbon.

Silica also combines with organic bases, ethyl and amyl, for instance, in a manner strictly analogous to their combinations with carbonic acid.

I next wish to call attention to the extremely coarse nature of even the most careful of chemical analyses. The majority of these when tabulated to show the percentage of the different constituents contained in a substance, do not pretend to go beyond two places of decimals, and even that is looked upon with distrust by those familiar with such matters, and no wonder, when we frequently see one and even two per cent. confessed as lost in the operation. Now, just let us endeavour to realize first of all what one per cent. of a substance means. Suppose we take a sphere, whose diameter is 10 inches, then 1 per cent., or the $\frac{1}{100}$th part of this mass, will be a sphere whose diameter is 2·1544 in., more than $2\frac{1}{8}$in.; and ·1 per cent., or the $\frac{1}{1000}$th part of the mass, will be a sphere whose diameter is 1in.; while ·0001 per cent. or the $\frac{1}{1000000}$th part of the mass, will still be a very appreciable quantity, namely, a sphere whose diameter is $\frac{1}{10}$ of an inch; the $\frac{1}{1000}$th part of this again, a sphere $\frac{1}{100}$th of an inch in diameter, and the $\frac{1}{1000000000}$th part of the 10in. sphere, would still be a mass distinctly visible to the naked eye.



This shows that the non-appearance of a substance in a chemist's analysis is not to be taken as any argument whatever in favour of its non-existence; it may exist, and in considerable quantity, and yet be quite ignored, particularly where the analysis has not been made expressly with a view to the determination of this particular substance.

My next fact is, that sea-water contains silica. That it does so we may fairly conclude from the fact that sponges secrete their siliceous spicules in it, and in it the Polycistinæ find the material for their beautiful siliceous shells. We also find analyses which directly show the existence of silica in brine springs, such as those of Worcestershire and Hesse, the salt beds from which the brine is derived being no doubt due to the evaporation of sea water; while Messrs. Abel and Bloxam, the chemists, say they find all waters contain silica, and that it is sometimes in combination with alkaline bases.

I must now remind you that the decomposition of mineral silicates, most notably of the felspars in granitic mountain regions, is probably caused by the action of carbonic acid and water upon them. They consist of silicate of alumina in combination with silicate of potash, soda, or lime, &c.; the carbonic acid displaces part of the silicic acid from its combination, forming alkaline carbonates, while the silicate of alumina becomes hydrated, and converted into kaolin or clay, which is washed down into the valleys.

Another instance of the decomposition of an apparently insoluble silicate by water and carbonic acid, may be seen in this piece of an old glass bottle; it appears to have owed its greenish tint to the presence of a little silicate of iron, which has been decomposed, and a thin film of ferruginous oxide left on the surface of the glass, causing, by its varying thickness, the iridescence that may be observed.

Another point, which will not be found irrelevant, is the anatomy of sponges. These are found to consist of an internal skeleton, a surrounding mass of jelly-like matter called the sarcode, and generally an investing dermal layer. The skeleton may be either calcareous, siliceous, or horny, and in each of these cases presents very different forms in different genera; in the two former generally consisting of spicules of most varied shape, and in the latter of solid anastomosing fibres. The sarcode may be either very scanty or very abundant, and the outward form of the whole sponge varies to such an extent that it seems scarcely to be restricted by any definable limitations. Some genera, as *Dysidea* for example, have the power, like some of the Foraminifera, of taking possession of, and building into their own structure, immense numbers of particles of siliceous sand, which they make subservient to their own purposes, in lieu of a self-secreted skeleton; and imbedded in the sarcode are generally found great numbers of foreign bodies, consisting of grains of sand, shells of Foraminifera, and the indigestible portions of other organisms which have been absorbed and assimilated by the sarcode as food.

Connected with this part of the subject is an important fact alluded to by Professor Huxley in a paper read before the British Association in 1868, in which, as well as I can ascertain, he stated that the bottom of the Atlantic Ocean, in some parts explored previous to the laying of the Atlantic telegraph cable, consisted of a slimy mud, and that its stickiness was owing to the presence of innumerable small masses of protoplastic matter, which, while living, were distinct from each other, but which, when dead, were merged together in a general slimy mass. In these small masses of protoplasm were imbedded the curious bodies known as *coccoliths* and *coccospheres*; the whole forming a paste of organic matter spread over the floor of the ocean to an unknown extent.

And now, gentlemen, my theory on the subject is briefly this:—To account for the formation of these substances, there is one solution of the problem which meets the difficulty, and only one. That it does so I hope some of you will be complacent enough to allow, but I have no expectation that it will pass altogether unchallenged. It is—in chemical language—the substitution of Si for C. We have seen the striking analogy that exists between these two substances; we have seen the power of carbonic acid to displace silica in the decomposition of felspar, an action constantly going on, and which, though slow in producing results, is nevertheless sufficient to account for the immense beds of clay which are almost invariably found underlying the peat bogs between granitic hills; and we now see the same power exerted in the formation of flints, almost without a difference; the nascent carbonic acid produced by the slow decomposition of organic matter, combining with the bases of the silicates in solution in the water, and setting free and precipitating the silica. But the matter is more simply stated by saying that carbon and silicon have changed places; this interchange being the result of what seems to be generally a determining cause of many rearrangements of chemical constituents, namely, the greater insolubility of one of the products; silica being, as you will of course perceive, a much more insoluble substance than either a soluble silicate or carbonic acid.

I take the case to have been thus:—The bottom of a deep ocean, generally free from currents, consisted of a tolerably level surface of foraminiferous mud, that is, of chalk mud, more or less consolidated; at all events of sufficient consistence to prevent sponges from sinking into it, and to allow of their growing upon it. It need not have been hard enough to afford attachment to their roots, for a sponge gemmule may attach itself to a loose fragment of shell, and when it has grown up enough to be top heavy, topple over, and then, by developing in another direction, quite enclose in its own mass the substance that served as its original anchorage.

Upon this sea bottom so constituted there grew a large crop of sponges, living and dying, growing and decaying, for a shorter or longer time. They were probably sponges consisting of a large amount of sarcode, strengthened by siliceous spicules, permeated by anastomosing canals, and invested by a dermal layer. Suddenly, by one of those changes in the condition of things, the cause of which I can well leave to your imagination, a temporary change of current brought with it from some other part, where they had been quietly subsiding, a perfect snow-drift of Foraminifera, fragments of *Inocerami*, and all the other shells that we find fossil in the Chalk, empty echinoderms, brachiopods, cephalopods, &c. The heavier pieces were bowled up against, and more or less pressed into the soft gelatinous sarcode of the sponges, while the smaller and lighter fragments settled down more gently, and entombed these unshapely masses of life, almost without distortion, in a mass of white calcareous mud.

It is to this burying alive they owe, in a manner, their salvation; for their fellow-sponges, not so buried, after fulfilling their several destinies, quietly rotted away; part of their substance being dissolved in the surrounding fluid, and the remainder dispersed by its slightest movement.

The entombed sponges, finding surrounding circumstances incompatible with the maintenance of life, died; and their component elements began resolving themselves into simpler combinations. It is at this point that the matter becomes most intensely interesting with regard to the present inquiry; for it is now that the liberated carbon changes place with the silicon; the nascent carbonic acid parts with its carbon in exchange for silicon, being converted into insoluble silicic acid, while the silicate of soda or potash becomes converted into a carbonate of the same base.

This quiet interchange of material went on without causing the slightest mechanical commotion amongst the constituent particles of the sponge, in such a way that all foreign carbonaceous matters imbedded in its substance were also converted into silica, while other matters not so convertible were simply retained imbedded in the mass of silica instead of in the mass of sarcode.

In this way we may readily and satisfactorily account for the presence and wonderful preservation of such delicate structures as the sponge gemmules, *Spiniferites*, or *Xanthidia*, the sponge spicules, the Foraminifera, &c., which occur much more plentifully than anyone would suppose who has not made the subject of flints his study, to say nothing of such comparatively huge masses as the fragments of shells of all sorts that we constantly see still sticking in them.*

In other parts the sea bottom was coated with the slime to which I have already alluded, and to which I understand Professor Huxley has given the name of *Bathybius*. This slime, reposing on a sandy or calcareous bed, the loose particles of which got more or less mixed up with its mass, was buried like the sponges in a sandy or calcareous sediment, after which it underwent the same change, and became converted, according to circumstances, either into sheets of chert, or tabular flint.

The veins or sheets of tabular flint that run in planes, cutting the planes of stratification diagonally, may, I think, be accounted for by supposing the sea bottom to have acquired considerable hardness, and then to have been fissured by internal heat, faulting, pressure, or other causes. These deep fissures would become at once a convenient habitat for sponge, which would accordingly form a coating over the two surfaces of the fissure; each coat growing in thickness until the two met in the centre, where, if the junction were not quite perfect, the chalk mud might find admittance into the interstices at the time of the general entomb-

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ment, as we actually find to have been the case; these diagonal veins almost invariably presenting the appearance of having been formed in two separate layers. This flint, like the others, also contains sponge spicules, *Xanthidia*, and Foraminifera; and the surfaces between the layers present much the appearance of what is commonly known as dermal membrane, that is, an interlacing of siliceous spicules into a sort of mat, with many spicules projecting from this mat into the gelatinous substance within, constituting, probably, an efficient protection to the sponge against some of its minor enemies. I may add that I consider the white crust of the Chalk flints in general to represent the dermal layer of the sponge, an inference which I have arrived at by investigation with the microscope, and which can only be satisfactorily brought home to the minds of others by the use of similar means. I have, however, some specimens here, which show in a very curious way a sort of flakey separation of this layer from the remainder of the mass.

In corroboration of this idea I may allude to the fact that the white crust is found where a dermal layer might reasonably be expected, and not found where such a layer would be superfluous. If the shell of an echinoderm, whose interior is filled with flint, be dissolved in acid, a most beautiful cast may be obtained, faithfully representing in the minutest details the sponge that formerly filled the cavity, and you may then see at a glance that every part of the sponge that came into direct contact with the salt water, and which, therefore, was furnished with a dermal layer, from the oral aperture down to the minutest pore of the ambulacra, has in the flint the white crust in question; while the parts which came in contact with the shell of the echinoderm, and which, being protected by it, needed no dermal layer, have no such white crust in the flint.

A great portion of the sponge spicules, as also the canals, have probably been obliterated by subsequent infiltration, one part of the flint having been melted down, as it were, to fill up the pores in another.

It is no real difficulty in the way of this theory to say that the conversion of the outer surface of the sarcode of a sponge into a thin crust of flint would protect the remainder from decomposition, and prevent its coming in contact with the siliceous solution. No such thing. The state of the pebbles in beds of gravel and shingle is ample proof of quite sufficient permeability for this purpose, and slow decomposition is one of the necessary conditions. There was is at this point that the matter becomes most intensely interesting with regard to the present inquiry; for it is now that the liberated carbon changes place with the silicon; the nascent carbonic acid parts with its carbon in exchange for silicon, being converted into insoluble silicic acid, while the silicate of soda or potash becomes converted into a carbonate of the same base.

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Many of the flints are hollow, and for this fact the hypothesis I have suggested readily accounts. A thin crust of silica was first formed on the outside of the sponge, not, however, an absolutely impervious coating; in structure, in fact, identical with that of the sarcode, and from this surface the silicification gradually extended inwards. But while this was going on the decomposition of the interior, in many cases, owing perhaps to peculiarities in the degree and solidity of imbedment, went on faster than the silica could be supplied to take its place, so that a certain portion of the interior was converted into actual gas, and made its way into the surrounding water or mud, either through some hole in the crust or by dissolving in the water that passed through the pores in its substance.

That these hollow spaces often contain a siliceous mass, structure, or powder, is not to be wondered at when we bear in mind the varying characters of the siliceous skeletons of sponges, which of course would not undergo decomposition at all; and at the same time the possibility that even keratose or horny skeletons, which would decompose much less readily than the sarcode, might in some cases be silicified by the same chemical process, after a portion, or even the whole of their surrounding sarcode had been converted into gas.

The reason why we so often see *Ventriculites* with the lower part silicified, while the upper part is not so, appears to be this—that the lower part was imbedded firmly in the chalk paste, which protected it during its decomposition; while the upper part, remaining exposed more or less to the action of moving water, the carbonaceous particles were removed by its action as fast as they decayed, and were mingled with, or dissolved in, the surrounding fluid.

The frequent occurrence of siliceous casts of echinoderms is readily accounted for on the supposition that the cavities of their empty shells furnished a suitable home for the growth of sponges, which in some cases partially, and in others entirely, filled up these cavities, often protruding in large masses through the oral aperture. These sponges being subsequently silicified in the manner suggested, would necessarily present the appearances we so frequently see. These flint casts contain sponge spicules, *Xanthidia*, Foraminifera, and other organisms, just in the same way as other flints.

The sheets of chert in the Purbeck Beds of Durlstone Bay, when examined by the microscope, are found to consist of a mass of *Cyprides*, with fresh-water shells, and probably a few diatoms. Clearly sponge had nothing to do with the formation of these beds; but the dead bodies of all these creatures, with probably many others that have left no marks of their individuality, formed a mass of carbonaceous animal matter, chemically of a very similar character to the sarcode of the sponges; and it is easy to see how, in their case, if placed in similar circumstances, their fate would be the same. A thick covering of silt and the presence of soluble silicates would be possible and efficient conditions. Probably any decomposing carbonaceous colloid placed in such circumstances would undergo the same change.

The silicification of wood becomes perfectly intelligible on the supposition of the chemical interchange that I have suggested. The carbon of the ligneous tissues is replaced by silicon; so that we have in some cases what may be called pseudo-morphic trees, as in those from the Portland "Dirt-bed," with the minutest details of microscopic structure faithfully maintained. There is some silicified wood in the Jermyn Street Museum, from the flinty chalk at Dover, which has been bored by the teredo, and the borings are filled with flint. In this case the occurrence of the wood in the Chalk at all is a much greater difficulty than its silicification. It was no doubt good solid wood when it was bored by the teredo, but subsequently got into such a rotten state as to allow of its sinking to the bottom of the sea. This rotten state of the wood will account for the specimens being much less dense than silicified wood in general. The borings subsequently became filled with sponge, and the whole buried in a foraminiferous drift, and silicified as before.

With regard to the silicified coral, apparently an *Astræa*, in the Jermyn Street Museum, from Antigua, I have not had an opportunity of examining it satisfactorily, but my impression is that it is not the calcareous structure which is replaced by silica, but that either the coral has been infiltrated by silica, or that the more animal portion of the living coral has been replaced by silica. That a mass of coral in such a neighbourhood as Antigua might be served in the same way as I have suggested with respect to the sponges, is easily conceivable. It is an island in which earthquakes are not very uncommon ; there was a notable one in 1843, and the island is described as surrounded by dangerous reefs. We have only to suppose some commotion sufficient to bury the masses of living coral in mud, and we have the necessary conditions at once.

It may be urged that sponges, even when coated with sarcode, are full of channels for the incurrent and excurrent streams of water, and that we find no such channels in flint; to which I reply firstly, that in some cases we do find channels in flints, although not generally; and secondly, that a very slight pressure on such a yielding substance as the sarcode of a sponge, possibly its own weight if dead, but at all events such as would readily be exerted by a very moderate amount of superincumbent mud, would speedily obliterate all signs of channels by squeezing the jelly into one general mass. Besides, many sponges, if hardened in the state they are in when first taken alive from the sea, as they may be by immersion in alcohol, become as solid and firm as a piece of liver.

Moreover, I do not mean to say that this theory alone accounts for all the phenomena connected with flints; it does not. There are numerous subsequent operations which they have undergone after their original formation, such as chalcedonic infiltration, which alone would go a long way towards the obliteration of all pores and channels, infiltration with metallic oxides, and the filling up of cavities with crystals of quartz and other minerals, or with agate.

The banded flints, so often found in beds of flint pebbles, are no doubt to be attributed in some cases to this cause. Cavities in the original flints have been subsequently filled up by deposition of fresh siliceous material in parallel layers, which, as they varied, either in their chemical composition, or rate of deposition, show, when broken across, bands of different colours and of different degrees of hardness. Some of the banded pebbles, however, are, I suspect, rounded fragments of chert, which, in the Mountain Limestone districts in particular, often has a finely banded structure.

The idea that flints were formed in a manner analogous to the formation of *septaria* nodules in the London Clay, that is by segregation of siliceous matter, furnished by the solution of infusoria, is perhaps in some degree supported by the fact, that although the Chalk Marl, in which I believe no flints are found, abounds with the remains of these siliceous organisms, yet that in the White Chalk, where layers of flint occur, their remains are comparatively rare; the inference drawn being that the siliceous infusoria, which it is taken for granted were originally equally numerous in both deposits, were, in the latter case, used up in forming the flints.

It is worth noting, however, although it is not necessarily an antagonistic fact, that the investigation of Professor Rose showed the silica of diatoms to have a specific gravity of 2·2, while that of flint, quartz, chalcedony, and sandstone was 2·9, an important difference.

But with regard to the theory that flints are concretions, I must say that I cannot see anything in them to support the idea. A flint that has not been exposed to the weather, one fresh from its chalk matrix, shows no indications of concentric arrangement in its structure. Any fragment of shell imbedded in it appears to be placed in a position quite irrespective of the centre of the mass; that is, it never appears to have served as a nucleus; while the curious fingers and toes which project from the nodules, so unlike anything in true concretions, such as *septaria*, seem to preclude the possibility of their having had such an origin. Moreover, that they are not concretionary, is clear from their not containing Foraminifera in anything like the same proportion as the surrounding chalk, but only as it were a few which have got imbedded in the sarcode of the sponge.

That previously existing siliceous particles had no power to determine the deposition of the silica, is pretty evident from the fact of isolated sponge spicules still existing in the chalk that surrounds the flints; which, if this supposition had been correct, would surely have lost their identity, and have become surrounded by, and imbedded in, either chalcedony or crystalline masses of quartz.

The change that I suppose to have taken place is a true pseudomorphic change; the original form is retained, though the material is altered. The same thing is common in inorganic nature, and has been particularly observed in the case of crystals. Thus quartz, for instance, is seen with the crystalline form of calcite, fluorspar,* gypsum, galena, pyrites, &c., occupying the place of crystals of those substances, for which it has been substituted; while numerous other substances, besides silica, have the power of permanently replacing the elements of organic structures, such as calcite, fluor, pyrites, copper, &c. It seems to me to be a very simple action, and

* There is a fine specimen of this at the Museum, in Jermyn Street.

to bear a striking analogy to one in constant use in the chemist's laboratory for the production of hydrogen gas. Dilute sulphuric acid is poured upon metallic zinc, the gas is quickly liberated, and sulphate of zinc remains in the solution. The philosophy of the matter is simply this—that the metal zinc and the metal hydrogen change places ; the sulphate of hydrogen, commonly known as hydrated sulphuric acid, becoming sulphate of zinc, and the metal hydrogen, which is a gas, being liberated.

In the case of the flints, probably the organic substance, consisting of C, H, and O, &c.,—please call it a carbonate of hydrogen for the present,—became converted into Si, H, and O,—say silicate of hydrogen;—while the soluble silicate, consisting of Si, Na, and O, the silicate of sodium, became changed into C, Na, and O, or carbonate of sodium.

The formation of pyritous and phosphatic fossils is probably due to a somewhat similar case of substitution.

In conclusion, I would suggest to those who have the time and means at their command for making experiments, that it would be worth while to try the effect of soluble silicates on decomposing organic matters. For if, as I imagine, the production of flint can thus be imitated artificially, the importance of the fact in its bearing upon the arts and manufactures can scarcely be over estimated. The coating of surfaces of perishable material with thin films of flint, for the purpose of protecting them from the action of the weather, would find constant employment for such applications. The imbedding in calcareous or argillaceous mud is easily imitated, and, as regards the pressure of an immense depth of superincumbent water, I do not think it is a matter of much importance; it does not seem to make much difference in other matters; animals live very comfortably under three or four miles of water, apparently as unconscious of the fact as we are of the 45 miles of air that press upon us.

A jar or tank provided with a drain-pipe, and stop-cock at the bottom, might be filled with water containing silicate of soda in solution; a layer of carbonate of lime could then be spread over the bottom by subsidence, either powdered chalk or common whiting would do, and upon that the organic bodies to be experimented on might be placed; of course some living or recently killed sponges should be of the number, and I would suggest some slugs, earthworms, and other soft-bodied, easily decomposable animals ; also some small plaster casts, textile fabrics, &c., coated or impregnated with size, albumen, flour, or other carbonaceous organic substance. Upon these might be spread again another layer of chalk powder, to a sufficient depth to prevent motion amongst the particles surrounding the objects; and then the whole should be left undisturbed for a considerable time. If several jars were prepared in this way, they might be examined after different intervals, so as to note the difference in result after shorter or longer subjection to the treatment. The stop-cock would serve to draw off the water from which the silica had been withdrawn, so as to allow of the addition of more silicate, without disturbing the objects.

By treating either of the objects with nitric acid on removal, it could be readily ascertained to what extent the conversion had proceeded.

Of the so-called "orbicular silica," I did not intend to speak this evening, my only knowledge of it having been derived from a hasty glance at a specimen Professor Morris was kind enough to show me some time ago. But on Thursday last, after I had sent in my paper, I suddenly discovered amongst my specimens a flint cast of *Holaster planus* from Caterham, part of which presented this peculiar appearance. I have carefully examined this specimen; part of it has been exposed to the action of the weather, part has not. The part that has been so exposed presents the markings known as orbicular silica; the part that has not been so exposed does not present any such markings. I infer, therefore, that the markings are produced by the weather, and indicate the structure of the sponge that filled the cavity; also, probably, that the siliceous matter subsequently infiltrated into the mass, or certain portions of the mass, independently of any such infiltration, were more readily removed by atmospheric agents than other portions. The markings appear to be concentric rings round the ends of the canals, and show that the sarcode must have been arranged in layers around them in this concentric manner.

Possibly the central spot of each group of curves may represent the sponge gemmule or germ when it first settled in its permanent abode, and the surrounding layers or lines, its growth by the addition of successive layers. Some of the sponges from Upware and Farringdon have a structure of this character.

Since writing the above, I have found similar markings on the chert from the Portland Stone quarries, in the Isle of Portland, and in all the cases I have observed the surfaces seem to be weathered casts of fossil shells, which, if it should prove to be invariably the to bear a striking analogy to one in constant use in the chemist's laboratory for the production of hydrogen gas. Dilute sulphuric acid is poured upon metallic zinc, the gas is quickly liberated, and sulphate of zinc remains in the solution. The philosophy of the matter is simply this—that the metal zinc and the metal hydrogen change places ; the sulphate of hydrogen, commonly known as hydrated sulphuric acid, becoming sulphate of zinc, and the metal hydrogen, which is a gas, being liberated.

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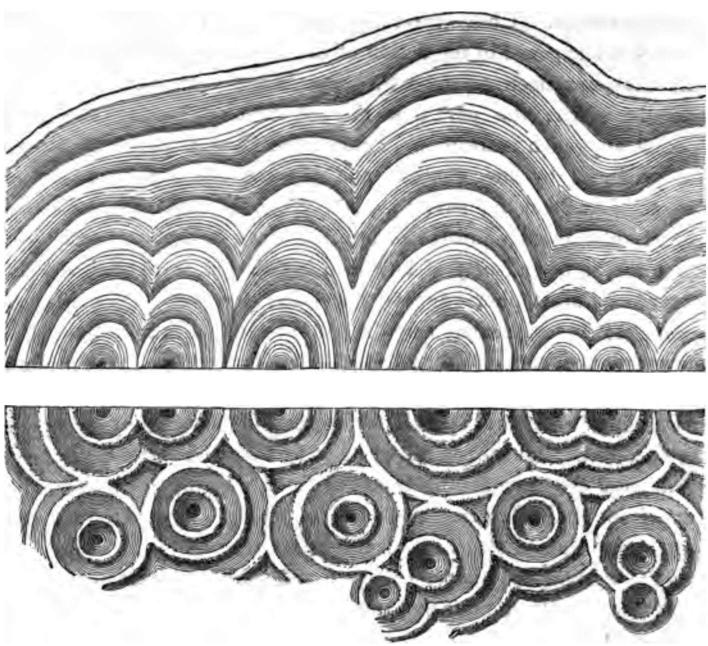
By treating either of the objects with nitric acid on removal, it could be readily ascertained to what extent the conversion had proceeded.

Of the so-called "orbicular silica," I did not intend to speak this evening, my only knowledge of it having been derived from a hasty glance at a specimen Professor Morris was kind enough to show me some time ago. But on Thursday last, after I had sent in my paper, I suddenly discovered amongst my specimens a flint cast of *Holaster planus* from Caterham, part of which presented this peculiar appearance. I have carefully examined this specimen; part of it has been exposed to the action of the weather, part has not. The part that has been so exposed presents the markings known as orbicular silica; the part that has not been so exposed does not present any such markings. I infer, therefore, that the markings are produced by the weather, and indicate the structure of the sponge that filled the cavity; also, probably, that the siliceous matter subsequently infiltrated into the mass, or certain portions of the mass, independently of any such infiltration, were more readily removed by atmospheric agents than other portions. The markings appear to be concentric rings round the ends of the canals, and show that the sarcode must have been arranged in layers around them in this concentric manner.

Possibly the central spot of each group of curves may represent the sponge gemmule or germ when it first settled in its permanent abode, and the surrounding layers or lines, its growth by the addition of successive layers. Some of the sponges from Upware and Farringdon have a structure of this character.

Since writing the above, I have found similar markings on the chert from the Portland Stone quarries, in the Isle of Portland, and in all the cases I have observed the surfaces seem to be weathered casts of fossil shells, which, if it should prove to be invariably the case, lends strong support to the solution of the mystery which I have suggested.

Mr. Bedwell, one of our members, has been kind enough to call my attention to some very beautiful markings on some flints in his collection, which appear to be due to the same cause, although they are much larger, and the sections are taken in various directions. These markings were, I understand, described by Mr. Wetherell some years ago as "winder markings." Diagrammatically the matter may be represented thus: a number of sponge gemmules settled on some surface suitable for their habitation, and commenced growth by the deposition of successive layers of sarcode around elongating axes. After a time the independent sponges came in contact with each other, and amalgamated, the subsequent layers covering in several axes instead of one only, until at last all the separate sponges were included in one mass. The layers may represent seasons or periods of growth, like the rings of wood in dicotyledonous trees; and certainly there are differences in the parts of each layer, for the weather, by removing some parts more readily than others, brings out this structure in relief.



Ideal Section and Plan, to show the origin of the markings known as Orbicular Silica, and the structure of the flints on which they occur.

Some of the banded flints, more commonly so called, may also owe their origin to a similar cause. Possibly after the formation of a bed of flints, the chalk mud above them may have been removed again, a current may have denuded them, and some of their cavities may have been filled with fresh growths of sponge in layers; which, submitted to a repetition of the same treatment, would produce the effects observed.

I think I have now said enough to show the state of my own ideas on the subject, and perhaps to lay myself open to hostile criticism; but if it shall prove that I have also managed to provoke those who are better informed to come forward and throw light on the subject, I shall not regret having forced the discussion.

Before I sit down permit me to add a few words, which will, I think, carry conviction to your mind more certainly than anything I have read to you. I am under the impression that I have made a flint—and can produce it. During the last few days I have submitted a tadpole to the process I have just suggested to you, and this afternoon I placed it in strong nitric acid for two hours and a half. The acid does not appear to have had any effect upon it, and I therefore conclude that the animal has been silicified to a sufficient extent to protect it from the action of the acid. The specimen is in this glass tube for your inspection.

SUPPLEMENT TO "CATALOGUE OF SPECIES IN THE ENGLISH CRAGS," (page 202). By ALFRED BELL, Esq.

Since the paper "On the English Crags and the Stratigraphical Divisions indicated by their Invertebrate Fauna" was published, I have obtained several fresh forms. These I have added to the new species described in Mr. Searles V. Wood's "Supplement to the Crag Mollusca," just issued, making such alterations as seemed advisable. To complete the lists of the Pliocene fauna I give also the fossils of the Diestien ironsands, and those which I think may be derived from the "Black Sands" of Belgium.

LOWER CRAG.

MOLLUSCA.

Actæon subulata, *Wood.*
Cæcum liratum, *Carp.*
Cancellaria cancellata (?), *L.*
" spinulosa, *Broc.*
Capulus recurvatus, *Wood.*
Cerithiopsis lactea (?), *Moller.*
Cerithium (?) aberrans, *Wood.*
Chemnitzia clathrata, *Jeffr.*
" elegantior, *Wood.*
" fulvocincta, *F. & H.*
" similis, *Wood.*
Chiton discrepans (?), *Brown.*
Cyclostrema lævis, *Phil.*
Dentalium entalis, *L.*
Eulima bilineata (?), *Alder.*
" intermedia, *Cant.*
" stenostoma, *Jeffr.*
Eulimella acicula, *Phil.*
Fusus elegans, *Charlesw.*
Helix Suttonensis, *Wood.*
Homalogyra atomus, *Phil.*
Menestho lævigata, *Wood.**
Murex Canhami, *Wood.*
Natica Alderi, *E. F.*
Niso pusilla (?), *Say.*
" (? sp.)
Odostomia albella (?), *Lovén.*
" conspicua (?), *Alder.*
Pleurotoma crispata, *Jan.*
" rugulosa, *Phil.*
Rissoa abyssicola (?), *E. Forbes.*
" eximia, *Jeffr.*
" senecta, *Wood.*
Trochus turgidulus (?), *Broc.*
Turritella subangulata, *Broc.*
" (?) penepolaris, *Wood.*

POLYZOA.

Apsendesia cerebriformis, *Blainv.*
Cellepora echinata, *Michel.*
Multizonopora ramulosa, *D'Orb.*

* I do not consider this to be my M. Britannica. I have seen both forms from Sutton.

MIDDLE CRAG.

Ursus arvernensis, *Croizet.*

ECHINODERMATA.

Echinus miliaris, *Leske.*
Temnechinus (?), sp.

MOLLUSCA.

Cæcum glabrum, *Wood.*
Chemnitzia rugulosa, *Wood.*
Fusus Turtonis, *Bean*
Murex Canhami, *Wood.*
Nassa incrassata, *Strom.*
" granifera, *Duj.*
Pleurotoma nebulosa, *Wood.*
Purpura incrassata, *Sow.*

POLYZOA.

Defrancia rugosa, *Busk.*
Retepora simplex, *Busk.*
Lepralia unicornis, *Johnst.*

CŒLENTERATA.

Trochocyathus anglicus, *Dunc.*

UPPER CRAG.

* These occur also in the Norwich or Fluvio-marine Crag. † Only found in the same. No Mammals are recorded from the purely marine beds of this age. ** Species common to the Middle and Norwich Crags only.

MOLLUSCA.

**Actæon Noæ (?), *Sow.*
†Fusus Actoni, *Wood.*
,, Woodwardi, *Wood.*
Limnæa Pingelli (?), *Moll.*
*Nassa pusillina, *Wood.*
Natica proxima (?), *Wood.*
*Pleurotoma assimilis, *Wood.*
*Pleurotoma equalis, *Wood.*
,, lævigata, *Phil.*
,, nebulosa, *Wood.*
,, quadricincta, *Wood.*

POLYZOA.

Heteropora pustulosa, *Busk.*
Lepralia innominata, *Couch.*
Salicornaria sinuosa, *Hass.*

CHILLESFORD SERIES.

Chemnitzia plicatula, *Broc.*
,, rugulosa, *Wood.*
Eulimella acicula, *Phil.*
Fusus contrarius, *L.*
Hydrobia subumbilicata, *Mont.*
Margarita argentata, *Gould.*
Natica Greenlandica, *Beck.*
Paludina (?) glacialis, *Wood.*
,, vivipara, *L.*
Pleurotoma assimilis, *Wood.*
,, Dowsoni, *Wood.**
Scalaria Trevelyana, *Leach.*

* The *P. exarata* of preceding lists.

FOREST BED.

Cervus carnutorum, *Laugel.*
,, verticornis, *Dawkins.*
Elephas primigenius, *Blum.*

CORRIGENDA IN MR. WOOD'S SUPPLEMENT.

[1]Aclis Walleri = Alvania albella, *Leach.*
Cæcum tracheum = C. tumidum, *Carp.*
[1]Cancellaria Bonelli. var. Dertonensis = C. gracilenta, *Wood.*
Capulus militaris = C. recurvatus, *Wood.*
Emarginula crassa (Lower Crag) = E. crassalta, *Wood.*
[2]Eulima distorta = E. similis, *D'Orb.*
Odostomia similimma = O. ornata, *Wood.*
Pleurotoma porrecta = P. inermis, *Partch.*
,, carinata = P. modiola, *Jan.*
[1],, pannum = P. bipunctula, *Wood.*
[3]{,, semicolon / ,, galerita} = P. Icenorum, *Wood.*
Paludestrina (genus) = Eulimene (G.), *Wood.*
Rissoa pulchella = R. semicostata, *Woodw.*
Scalaria varicosa = S. funiculus, *Wood.*
Triton heptagonum = T. connectans, *Wood.*

[1] I do not adopt these alterations. [2] Adopted, *E. distorta* being preoccupied by an Eocene form. [3] Prof. Von Kœnen has already named this shell *P. Hosiusii.*

FOSSILS OF THE DIESTIEN SANDS OF KENT AND SURREY, AND THE SUFFOLK BOXSTONES.

[For some further particulars of the relations borne by these fossils to those of the Black Sands, see "Geological Magazine," June 1872, pp. 210, 211.]

Mastodon.	Serpula.	Buccinum.
Cetacea. (2 sp.)	Balanus.	Bulla.
Crocodilus.	Coronula.	Calyptrea.
Carcharodon, &c.	Buccinopsis.	Cassidaria.

Cerithium.
Conus.
Dentalium.
Desmoulea.
Emarginula.
Fusus. (2 sp.)
Natica. (3 sp.)
Nassa. (2 sp.)
Phorus.
Rissoa.
Pyrula.
Pleurotoma. (2 sp.)
Rostellaria.
Scalaria.
Terebra.
Turritella.
Trochus. (2 sp.)
Voluta. (2 sp.)
Arca.
Astarte. (4 sp.)
Cardium. (4 sp.)
Cardita.
Cytherea.
Cyprina. (2 sp.)
Cyrena. (?)
Crassatella.
Donax.
Diplodonta. (?)
Glycimeris.
Isocardia.
Kellia vel Lepton.
Lucina.
Lutraria.
Leda. (2 sp.)
Mactra.
Modiola.
Mya. (2 sp.)
Nucula. (3 sp.)
Ostrea.
Panopea.
Pecten. (3 sp.)
Pectunculus. (2 sp.)
Pinna.
Solen.
Syndosmya. (2 sp.)
Thracia.
Tapes.
Tellina.
Venus.
Woodia.
Terebratula.
Polyzoa (several species).
Turbinolia.
Clione.
Spines of Echini.

Black Sand Fossils Found in the Middle Crag.

These are the species referred to on p. 190, as being probably derived from the Black Sands (see also "Geol. Mag.," May, 1872).

Ancillaria glandiformis, *Lam.*
Cancellaria Bellardi (?), *Mich.*
,, Bonellii (?), *Bell.*
,, Charlesworthii, *Wood.*
Cassis saburon, *Brug.*
Cerithium, sp.
Desmoulea conglobata, *Broc.* (?)
Fusus abrasus, *Wood.*
,, crispatus, *Borson.*
Mitra fusiformis, *Broc.*
Murex exculpta, *Duj.*
Phorus.
Pleurotoma ambigua, *Wood.**
,, coronata (?), *Bellardi.*
,, interrupta, *Broc.*
Pleurotoma intorta, *Broc.*
,, nodifera (?), *Lam.*
,, senilis, *Wood.*
,, turrifera, *Nyst.*†
Ranella anglica, *A. Bell.*
Rostellaria plurimacosta, *Wood.*
Scalaria semicostata, *J. Sow.*
Solarium vagum, *Wood.*
§Vermetus Bognoriense (?), *Sow.*
§Voluta nodosa (?), *J. Sow.*
§ ,, luctatrix, *Sol.*
§Turritella imbricataria, *Lam.*
Tellina Benedenii, *Nyst.*
Solenastrea Prestwichii, *Duncan.*
Flabellum, sp.

* The fragment figured by Mr. Wood, as *Pl. arctica* (?), is, I am now satisfied, a different species, and I have adopted Mr. Wood's name. I have seen the true *P. arctica* from the Middle Crag, Loc. Waldringfield.

† This is the *Pl. contigua* in the preceding lists.

§ Possibly these are Eocene shells.

EXCURSION TO ILFORD AND VISIT TO SIR ANTONIO BRADY'S MUSEUM, June 17th, 1871.

Directors—Henry Woodward, Esq., F.G.S., F.Z.S., and Sir Antonio Brady, F.G.S.

A large number of Members of the Association assembled at Bishopsgate Station, and proceeded by the Great Eastern Railway to Ilford, from which place a walk of less than a mile brought the party to the Uphall Brick Field, where is seen one of the exposures of the Mammaliferous Brick-earth of the Thames Valley, which have rendered this locality famous for the remains of the larger Mammalia of the Pleistocene period.

Arrived at the pit, Mr. Henry Woodward briefly described, and illustrated by a diagram, the Pleistocene or Post-Pliocene deposits of the Thames Valley. Mr. Woodward stated his general agreement with the views expressed by Mr. Searles V. Wood, jun., on these beds, and referred his hearers to that gentleman's paper "On the structure of the Thames Valley, and of its contained Deposits," in the "Geological Magazine," vol. iii., page 57, in which is given a descriptive account of the groups into which Mr. Searles Wood has divided these deposits, and which are named as follows :—

5. The Forest and Peat Bed.
4. The Grays Brick Earth.
3. The Upper Brick Earth.
2. The Thames Gravel.
1. The Lower Brick Earth.

Mr. Woodward agreed with Mr. Wood in considering the Ilford deposits to be older than the beds at Grays. Though Elephant remains have been abundantly obtained from both these localities, yet there is a remarkable difference in the distribution of the species; for while *Elephas primigenius* is the common species at Ilford, it is very rare at Grays, where *Elephas antiquus* is found taking its place. In addition to *Elephas primigenius*, the beds at Ilford yield sixteen other species of Mammalia (see "Proc. Geol. Assoc.," vol. ii., p. 230). These have been taken chiefly from the Lower Brickearth underlying the great sheet of the Thames Valley Gravels, which is covered in some places by the Upper Brickearth, having a thickness of from five to eight feet.

The Upper Brickearth extends over considerable areas in the Thames Valley, and is especially well seen about Wanstead, West Drayton, and Tottenham, but it is by no means rich in organic remains. The lower beds at Ilford yield abundantly, in common with the Grays and the Crayford deposits, *Corbicula (Cyrena) fluminalis.* At the conclusion of Mr. Woodward's lecture, the Members spent a little time in collecting the characteristic species, many very fine specimens of which were obtained. The London Road pits were then visited, and the sections at this place—very similar to the Uphall exposures—were examined.

The party now returned to Ilford, and subsequently proceeded to the residence of Sir Antonio Brady, for the purpose of inspecting the magnificent Collection of Mammalian Remains which that gentleman possesses, and which have been derived almost exclusively from the Uphall and London Road pits of Ilford. The teeth of perhaps one hundred elephants are in this Museum, and attest the abundance of these great pachyderms at one time inhabiting the Thames Valley. Sir Antonio Brady, after pointing out the more important specimens in his Collection, gave his visitors a very interesting account of the manner in which the large specimens (some of great weight) were exhumed. While *in situ*, the bones are so fragile that it is necessary to take the greatest possible care lest they fall to pieces while being removed, and in some cases it is requisite to remove with the bones large quantities of the earth in which they are imbedded. A fine collection of stone implements and antiquities was also inspected by the Members, who were subsequently most hospitably entertained by Sir Antonio Brady, and a very pleasant evening terminated an interesting and instructive excursion.

EXCURSION TO CATERHAM JUNCTION AND RIDDLESDOWN, July 1st, 1871.

Director—J. Logan Lobley, Esq., F.G.S.

(*Report by Mr. Lobley.*)

On arriving at Caterham Junction at the north end of Riddlesdown the party examined the fine section of the Upper Chalk there exposed. Riddlesdown is a long, bold hill, running east and west, formed by the uprise of the Chalk on the north of the Wealden

Area, and is a portion of the great range of Chalk hills which extends from Dover on the east, to Farnham on the west, known by the general name of the North Downs. The section at the northern end of the down shows a vertical face of the Upper Chalk with characteristic lines of nodular flints, as well as a good example of horizontal tabular flint. This being a north and south section, and extending for a considerable distance, the true general dip of the Chalk forming the North Downs, a slight one to the north, is very distinctly seen, although at one place, in consequence of a local dislocation, the beds have for a short distance a contrary inclination.

The sequence of the geological formations comprised in the Cretaceous System, the denudation of the Weald, and the physiography of the country between London and Brighton having been explained and illustrated by diagrams, a brief exposition of the views held by Mr. Caleb Evans on the sub-divisions of the Chalk was given. The opinions held by Mr. Evans with respect to the establishment of Life Zones in the Upper and Lower Chalk are fully stated in his paper "On Some Sections of Chalk between Croydon and Oxtead," published by the Association. Before leaving the section the Members prosecuted an active search for fossils. *Spondylus (Plagiostoma) spinosus*, appeared to be the most abundant species at this place, though the usual Upper Chalk echinoderms *Ananchytes ovatus* and *Micraster cor-anguinum*, are frequently met with. Leaving this section, the party proceeded by a path along the side of Riddlesdown, from which the streamless Chalk valleys, on the south and east are well seen, to the southern mouth of the unfinished tunnel on the abandoned Surrey and Sussex railway, and the interesting sections to be seen at this place were carefully observed.

The Chalk forming Riddlesdown dipping normally slightly to the north, the beds on the southern are lower geologically than those on the northern side of the hill. In accordance with this difference in geological position, it has been found by Mr. Evans that the beds at the southern mouth of the tunnel under the down are palæontologically differentiated from those at the northern mouth, *Micraster cor-anguinum* and *Ananchytes ovatus* being the most noticeable species at the former section, while *Inoceramus Cuvieri* prevails at the latter. To the beds at the southern mouth of the tunnel, Mr. Evans has given the name

"Upper Kenley Beds," reserving for others lower and nearer to the village of Kenley the appellation "Lower Kenley Beds." The flint, which is almost universally associated with the Upper Chalk, occurs here in the tabular as well as in the nodular form, and the tabular is both horizontal and vertical. It was observed that in some cases one form appeared to pass into the other, and a sheet of horizontal tabular flint was found to be terminated by a vertical vein. Mr. Evans writes of this section—"Immediately within the tunnel mouth on the east side a fault is seen, which throws down the beds at least one foot two inches towards the south. The direction of this fault is from S.W. to N.E., and it may be well seen above the centre of the tunnel mouth, and also on the west side of the cutting; this fault probably gives rise to the undulations of the yellow band in the upper cutting. In the beds immediately above the tunnel mouth one side of this fault is exposed, and presents a very remarkable example of the rubbed surface known as 'slickensides.' The grooves and ridges in this instance are in a horizontal and not vertical direction, denoting a lateral shifting of the beds in addition to the vertical displacement."

The fineness of the weather and the beauty of the surrounding country, seen to great advantage from this commanding eminence, induced the Members to linger on the sunny summit of Riddlesdown, and, before leaving, the party was joined by Mr. Caleb Evans, who described the Chalk of the district, and exhibited specimens of some of the characteristic species of its various beds. A pleasant walk through the shady lanes on the northern slope of the hill brought the Members to the Brighton Road, not very far from Croydon, and the great exposure of the Chalk in the quarry on the west of the road was examined, and some fine specimens of *Dercetes elongatus*, which fish appears to be abundant here, were obtained. At this place, it is worthy of remark, was found the granite boulder, the presence of which, in undisturbed Chalk, led Mr. Godwin-Austen to the inference that glacial action had not been altogether wanting in these latitudes during the Cretaceous Period, and that this block of granite, apparently of Scandinavian origin, had been dropped from an iceberg floating on the surface of the ocean of that epoch. This was the last section visited, and the party shortly afterwards returned to London.

ORDINARY MEETING, July 7th, 1871.

Professor Morris, F.G.S., H.M.G.A., Vice-President, in the Chair.

The following Donations were announced :—

"Journal of the Quekett Microscopical Club," from that Club.

"Abstract of Proceedings of the Geological Society," from that Society.

"The Thirty-Seventh Annual Report of the Royal Cornwall Polytechnic Society for 1869," from that Society.

"The Thirty-Eighth Annual Report of the Royal Cornwall Polytechnic Society for 1870," from that Society.

The following were elected Members of the Association :—

John Gould Avery, Esq., M.A.I.; John Barber, Esq.; William Bartlett, Esq., F.R.C.S.; Ralph Augustus Busby, Esq.; Lieut.-Col. Capel Coape; Henry Monk, Esq.; George Staley Mosse, Esq.; John E. L. Shadwell, Esq., M.A.; George William Spawforth, Esq.; and Mrs. Peter Taylor.

The following Papers were read :—

1. On the Upper Limits of the Devonian System.

By S. R. Pattison, Esq., F.G.S.

I am not about to revive the controversy in which the late lamented Mr. Jukes maintained with distinguished gallantry for so many years that the Upper Devonian had no existence. This dispute is settled. Devonian has conquered. The careful work of Mr. Etheridge, crowning the labours of a band of distinguished Devonians, has demonstrated that the Devonian System is a great triple natural history division. It was dragged out of the ocean of Grauwacke in 1836, after having been seen by Mr. Lonsdale, held up to public view by Sedgwick and Murchison, at the British Association of that year, and has duly passed into the literature of Continental and American geology.

I have a few words to say this evening on the district in which it was first determined.

Referring you, then, to North Devon, and reminding you that the opening of the new railway from Taunton to Barnstaple will render the country more accessible than it is at present, I take you down by the old route. From the rich red marl of the Taunton Valley, going south, we first encounter a set of coarse schistose sandstones, the Foreland, extending over the hill to the picturesque gorge of Lynton; next, and from there, a range of rocks, somewhat less coarse, including the limestones of Coombe Martin, the thin representation of the great Eifelian, Plymouth, and Torbay calcareous masses. Here we have a good horizon, and we call it Middle Devonian, having thrown the series just passed through, with a southerly dip, into the category of a Lower Devonian. The Ilfracomb Series ends upwards in another set of hard sandstones (Pickwell Down), and upon these lie an uppermost series of shales, and lumps of limestones, and grey beds, extending to the base of the carbonaceous rocks, and these we term Upper Devonian. Thanks to the discrimination of the late Mr. Salter, we are at no loss as to the Upper Devonian in North Devon. They may be called the "Barnstaple Beds," by way of distinction. They extend from the town to the edge of the carbonaceous series, and thence outward to the cliffs at Crouch Bay. The section runs thus, in ascending order. 1. Purple slate and sandstones. 2. Pale slate with a few bivalves. 3. Grey grit, a thick series. These three form the Marwood beds. Then 4, an alternating series of greenish-grey grits, or grey cleaved slate—the Pilton Beds. The Upper Devonian is both stratigraphically and palæontologically here divided into two groups, the upper, Pilton; the lower, Marwood. The uppermost beds touch the carbonaceous limestone, which, however, overlaps different beds on its line. The Marwood Group is a shallow sea accumulation; it displays a distinct Devonian fauna. I do not trouble you with lists of fossils. They will be found admirably arranged by Mr. Etheridge, but were also well characterised by Mr. Salter. In the green slates of this series plants occur. The Pilton Group contains an analogous fauna, sufficiently distinguished. These are the typical displays of the Upper Devonian. This stratigraphy has been well established, and the fossils render the matter certain. Mr. Salter's memoir, Quart. Journ. Geol. Soc., vol. xix., p. 480, will give all that is needed for the discovery, identification, and collocation of these beds.

If we now resume our progress southward, and cross the wide and dull expanse of lower carbonaceous clays and grits, with its thin fringe of limestone at the base, we find a rough basin of these *overlying* rocks, of which the lower or southern edge extends into

Cornwall, and runs east and west, a little north of Launceston. Emerging from under these, finding our latitude by the basement beds of grit and Carboniferous Limestone with coal plants, we first encounter a lower limestone with fossils, at South Petherwyn. Sedgwick and Phillips, and also De la Beche, placed these roughly on a parallel with the Barnstaple Beds. The fossils, they considered, though not identical as a whole, yet had a common facies. Salter did the same, though he considered them to form a lower group of the Upper Devonian, and treated a small intervening inlier near Yeolmbridge as the exact parallel of the Barnstaple Beds. If this be correct, we have a third series of the Upper Devonian, viz., the lowest, Petherwyn; the middle, Marwood; the uppermost, Pilton. I do not know the Pilton Beds from observation save from one very short morning's walk, and should be inclined to place the Petherwyn and Pilton as synchronous. But this is a matter of little importance in a formation so notoriously patchy as the Upper Devonian.

If either of these be correct, we have, as we go southwards through Cornwall, and pass over a set of beds having a general dip to the north, a triple series like that of North Devon :—the Petherwyn, or an approximate parallel to Barnstaple, Upper Devonian; the Plymouth, undoubted Middle Devonian; the Looe rock, Lower Devonian; and in addition the Gorran quartzites, Silurian.

But a recent and competent observer exclaims "*Nous avons changé tout cela.*" Dr. Holl, of Malvern, who in his youth explored these regions, has in his maturer age given them careful revision. He has embodied the results in a memoir "On the Older Rocks of South Devon and East Cornwall," Quart. Journ. Geol. Soc., vol. xxiv., p. 400. After much good work, he concludes that there is no Upper Devonian in Cornwall, and that the whole series is Middle Devonian, and thus he alters the received notions concerning a great part of Cornwall.

Mr. Holl's proposition is that the fossiliferous rocks of South Petherwyn have been erroneously assigned to the Upper Devonian, and that, on the contrary, they are Lower Devonian. He adduces two arguments in support of this. 1. That it is contrary to the actual section, as the rocks have a general north underlay at Petherwyn which, travelling southwards, is soon exchanged for a general south underlay as far as Plymouth, and therefore that the Plymouth Middle Devonian should come in south of the Petherwyn if this latter are Upper, which they do not, and therefore they are below the Plymouth Beds.

But this is by no means conclusive in so broken a country, and with so spotty a formation as the Upper Devonian. Especially as the intervening axis is the great granitic axis of Devon and Cornwall, which has faulted and disturbed the beds at some date subsequent to the deposition of the Carboniferous, and therefore we may have any amount of denudation as well as fracture exhibited in the old country. There are therefore five hypotheses, all of them true causes which may have prevented this :—1. The great granitic uplift. 2. Minor faults on the line of strike. 3. Denudation which has stripped off much of every bed. 4. Non-continuance of the Plymouth in the arch southwards; or 5thly, that the Petherwyn Beds are mere local patches in a synclinal trough of the Middle.

Mr. Holl's second reason is that the palæontological evidence of their being Upper Devonian is not conclusive, but capable of being used for either. Now this is a remarkable assumption, as Phillips, Salter, Etheridge, and others, who were fully alive to the distinction, have written, and spoken, and published otherwise, and that repeatedly. But of course authority is not argument. There are 73 good species found at Petherwyn, deducting three duplicates. Mr. Holl, for the purpose of comparison, first takes off 21 species peculiar to this formation. I demur to this proceeding, unless he gives the facies of these, and shows that it differs from that of the deposit to be identified. Amongst these 21 species which he eliminates occur eight *Clymeniæ*, a *Goniatite*, and a *Nautilus*, all peculiar to Petherwyn. Why, for purposes of identification should these be left out? If they have no brothers elsewhere, they have cousins. The family likeness of the 21 does not point downwards into Lower Devonian, but upwards to the continental uppermost Devonian, and even aspires to the Carboniferous. The very circumstance which induced the Irish Survey to put them up, leads Mr. Holl to sink them down. Then he excludes 10 others not found in British Devonian, viz—*Cypridina*, *Pterinea*, *Cardiola*, *Natica*, and *Loxonema tumida*. The same remonstrance must be offered against this extradition. The comparison becomes incomplete if these are left out. *Noscitur e sociis* is good for man and beast, especially with the Cephalopoda. The palæontologist gathers his impression from the group as a whole. On Mr. Holl's arrangement there are 40 species common to Petherwyn and Middle Devonian against 27 common to Petherwyn and Barnstaple. True, but the items omitted are precisely those which establish the difference—the Hamlets, which are the making of the play.

It would be tedious, and indeed improper here, to weary you with details. Speaking from the recollection of many years ago, I would characterise the Petherwyn as a deposit of some half dozen beds of impure limestone and slate, characterised by these 73 good species, all found in a small space. The beds are not now worked for lime, nor are any other quarries opened in them, and hence the opportunity of making fresh investigation is gone. A very few shattered and imperfect fossils may be found among the *débris* of the old quarries and in the beds along the line of strike.

These beds dip under the carbonaceous beds, which are close to them on the north, and strike, with the general run of the country, round the base of the granite. Towards Plymouth they are succeeded by lower barren sandstones, and the latter support them also on the opposite line of strike, north and north-west.

In trending round a larger development of some of the Petherwyn Beds may be occasionally traced to Tintagel, and by Delabole southwards to near Bodmin, whilst outside of these and below them occur at Padstow feeble representations of the Plymouth Series, and lower down, at Newquay, we are on the track of the Lower Devonians of Looe and Fowey. The great Eifelian limestone of Plymouth does not come in at all to the northward, until we come to the second great fold at Barnstaple. This brings the whole of that broken country into regular sequence, continued by the Silurian quartzites at Gorran, and everywhere on a north and south line crowned by the Carboniferous.

It will be useful in so rough a country geologically, so ill fitted for rapid conclusions, to inquire whether there are any analogous features in the Palæozoics elsewhere. The South Devon section I have not examined, but it is evident that the upper portion of the Newton limestones, though conformable to the lower, yet introduce a new set of organisms, and in a very thin way represent the commencement of Upper Devonian. This was Mr. Salter's opinion. In Pembrokeshire, in West Angle Bay, at the base of certain Old Red Sandstone beds, lie Carboniferous Slates, and in the lower portion of these, apparently quite conformable, are Upper Devonians.

In Ireland we have a largely developed series, with some characters differing—the Coomhola Grits, comprising both layers of the Upper Devonian., viz.—the Marwood and Pilton Beds.

On the Belgian frontier of France I have followed the Devonian from beyond Givet down the Meuse, and found small traces of anything above the Plymouth Limestone of Givet, until coming down to the district bordering the coal basin of Belgium. Then occur thin bands of intermittent limestone and heavy sandstones, called first by Dumont, "Psammites de Condros." I was directed to these by Mons. Gosselet, the accurate and conscientious Professor and Curator at the Sorbonne. Near Avesnes, at Oetrungt, the black Carboniferous Limestone is found in the near neighbourhood of a grey, thin, many-bedded limestone, which contains *Clymenia.* This attracted my notice, and I went to Oetrungt to ascertain, if I could, its conditions and relations. I could not make out all the beds which my friend Gosselet had pictured, but in general the quarry is like a Devonshire limestone quarry, with Upper Devonian types, and even some forms attributed to the Carboniferous Limestone. I exhibit a section showing the marvellous number of beds. Some of the same fossils occur throughout. Generally on the borders of the coal district we have either a great slaty series, the Famenne, or a thick sandstone with a few limestones at the base, or both. The latter are characterised throughout the Belgian and French area by the occurrence of *Terebratula (Rhynchonella) cuboides.*

In the Boulonnais the same thing occurs. I have seen there the yellow sandstone—Marwood—resting on Eifelian, or Middle Devonian slates and limestone, the Clymenian or Petherwyn being wanting.

On the Rhine and in Nassau the Upper Devonians are in force and well marked. Here they are not accompanied by the presence of Carboniferous Limestone. They are the well-known Cypridinian Schiefer, characterised by *Cypridina serro-striata,* found also at Petherwyn. Krammenzel-stein, or Ant-stone, Clymenia-kalk, the Petherwyn Group, and the Verneuilli-schiefer, together constituting the Marwood and Pilton Groups, the whole series of the Upper Devonians. Roemer divides it into 4 ("Siluria," p. 372), the lowest of which is the *Rhynchonella cuboides* bed of the French frontier, next the Clymenia-limestone, and above these the Goniatite-limestone, capped by Receptaculite schists, the whole corresponding to our Petherwyn and Barnstaple series. So in Westphalia there is Clymenia-limestone, and above it two beds compared to Marwood and the Pilton, or yellow-sandstone of Ireland.

In North America the Chemung and Portage Groups represent our Upper Devonian, and are well established; they are there, without question, held to constitute a good stratigraphical and palæontological division. There is no defined divisional plane between the Chemung and the Carboniferous Sandstone (Bigsby), *i. e.*, it is difficult to make out the division physically; but once *in* either, and you recognise the difference without doubt (Dana, 287).—See Dawson's picturesque, yet full and careful description in "Leisure Hour," May, 1871, p. 296.

From this sketchy review we have no hesitation in affirming the clear division of the Upper Devonian from the Carboniferous as a convenient natural history and stratigraphical division. The strata exhibit the sediments of deep sea bays, with occasional swamps and muddy shallows, and prove that this state of things was of long continuance, a kind of premonition of the Carboniferous. A new order of things was being gradually established, both physically and palæontologically, so that it is part of the case that the Upper Devonian should be the most transient and interrupted portion of a transition formation, the close of an era, not ending in storms, but in peace and mud.

It is hardly necessary to remind you that our so-called Systems have two artificial lines, viz., those which affect to separate them from the whole, and that it is the space thus artificially separated for examination that we call a System. Looked at in another aspect they are but parts of a whole; but for convenience we separate facts into collections and class together those which have general resemblances. The number of these resemblances augments towards a maximum by degrees, and descends by degrees; so that whilst the culminating line or point of these resemblances may be well and strongly made out, yet the edges will in the nature of things be shadowy and debateable.

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2. On a New Section of the Upper Bed of the London Clay.

By Caleb Evans, Esq., F.G.S.

(Abstract.)

The author drew the attention of the meeting to an exposure of a very fossiliferous bed of the London Clay, near Childs Hill, Hampstead.

In the higher parts of the Hampstead district the London Clay is nearly 400 feet thick, and it usually appears as a very stiff, dark brown, or grey clay, with many concretionary masses of argillaceous limestone known as *septaria*. The higher portion of the London Clay becomes coarser in character, and consists of a mixture of sand and clay.

Fossils are very abundant in this part of the deposit, and fine examples were obtained many years since from the cutting at the Highgate Archway.

In June, 1871, some drains were constructed in the Finchley Road, near Childs Hill, and the section then exposed, to the depth of 30 feet, showed at the bottom stiff, dark-coloured clay with *Modiola elegans*, passing up into grey sandy clay abounding with well preserved fossils, the most characteristic of which were *Pectunculus decussatus*, *Pecten corneus*, *Caridum nitens*, *Cytherea tenuistria*, and *Voluta nodosa*.

The highest part of the section consisted of brown clayey sand, derived probably from the disintegration of the bed below, and from the subaerial denudation of the neighbourhood.

EXCURSION TO WARWICKSHIRE, July 10th and 11th, 1871.

Directors—The Rev. P. B. Brodie, M.A., F.G.S., and J. W. Kirshaw, Esq., F.G.S.

Members proceeded by the Great Western Railway to Harbury Station, near Leamington, and were there met by the Honorary Secretaries to the Warwickshire Archæological and Natural History Society, the Rev. P. B. Brodie, M.A., F.G.S., and J. W. Kirshaw, Esq., F.G.S., who most efficiently acted as Directors of the Excursion. After partaking of luncheon kindly provided by Messrs. Greaves and Bull, the proprietors of the extensive Lias quarries and cement works of the neighbourhood, the party visited the quarries, where the Lower Lias is exposed to a depth of fifty feet for a quarter of mile, showing one of the finest inland sections of the Lower Lias in England. This may be considered a typical section of the "Lima-beds" of the Lower Lias, which are seen to consist of alternate beds of a bluish-white limestone, and dark-coloured shale and clay. The limestone is quarried for the manufacture of "hydraulic cement," but the clay is not here employed for any economic purpose, though in other places Lias clay is advantageously used for brick and tile making. Palæontologically, the Harbury Lias does not equal in interest the corresponding beds at some other localities. The *Gryphæa incurva* is not uncommon in the clay bands and *Rhynchonella variabilis* is the most abundant species in the limestone, while *Lima gigantea*, *L. Hermanni*, *Pecten-Pradoanus*, *Plesiosaurus rugosus*, and the genera *Ammonites*, *Nautilus*, *Ostrea*, *Perna*, and *Pinna*, are also, though sparingly, represented. The Members were invited to inspect the cement works, and afterwards the party proceeded northwards along the railway in the direction of Leamington to examine the fine section exposed in the railway cutting near Harbury. As the railway is nearly at right angles to the dip of the strata, which is a slight one to the south, beds lower than those seen in the quarry are exposed, and the section extending for upwards of a mile the lowest beds of the Lias, beds of the Rhœtic Series, and, still further, the Red Marls of the Trias are seen. After this very instructive section had been carefully observed, the train was taken for Warwick, and the Members re-assembled at the Woolpack Hotel, where they dined, and were briefly addressed by the President, Professor Morris, and the Rev. P. B. Brodie, M.A.

In the evening the Museum in the Town Hall, a building of great antiquity, was lighted with gas for the first time in its annals, to allow of an inspection of the very valuable collection of Triassic and other fossils there deposited, without any of the small number of hours of daylight at the disposal of the party being employed for the purpose. This was an honour to the Geologists' Association which the Members did not fail to appreciate. The organic remains from the Triassic rocks of Warwickshire, on account of their extreme rarity, give a special character and high palæontological value to the Warwick Museum. These fossils consist chiefly of the remains of Labyrinthodonts, of Ichnites or footprints of Cheirotherium, and of the little crustacean *Estheria minuta*, once thought to be a mollusc, and called for a time *Posidonomya minuta*. But in addition to these, the Warwick Museum contains a very fine typical collection of the characteristic fossils of each British formation, and is thus valuable alike to the more and to the less advanced student of Palæontology.

The following is a list of Organic Remains obtained from the

Trias of Warwickshire, and preserved in the Warwick Museum and the Collection of the Rev. P. B. Brodie* :—

PLANTÆ.			
Calamites	Upper Keuper	Rowington	W. M. & Col. B.
" ?	Lower Keuper	Warwick	W. M.
Echinostachys ?	Upper Keuper	Rowington	W. M. & Col. B.
Voltzia	Upper Keuper	Rowington	W. M. & Col. B.
Walchia ?	Upper Keuper	Rowington	W. M. & Col. B.
Calyx of plant	Upper Keuper	Rowington	Col. B.
Fruit (Carpolithus ?)	Upper Keuper	Rowington	W. M. & Col. B.
CRUSTACEA.			
Estheria minuta	Upper Keuper	Shrewley	W. M. & Col. B.
PISCES.			
Lophodus (teeth and spines)	Upper Keuper	Shrewley	W. M. & Col. B.
Palæoniscus superstes	Upper Keuper	Rowington	Col. B.
Skin of Shark	Upper Keuper	Shrewley	W. M. & Col. B.
REPTILIA.			
Cheirotherium (footprints)	Upper Keuper	Preston Bagot	W. M.
Cladyodon Lloydii	Lower Keuper	Coton End and Cubbington	W. M.
Hyperodapedon Gordoni	Lower Keuper	Coton End	W. M. & Col. B.
Labyrinthodon leptognathus	Lower Keuper	Coton End and Cubbington	W. M.
" pachygnathus	Lower Keuper	Coton End and Cubbington	W. M.
" salamandroides	Lower Keuper	Coton End and Cubbington	W. M.
" ventricosus	Lower Keuper	Coton End and Cubbington	W. M.
Rhynchosaurus (footprints)	Upper Keuper	Shrewley	W. M. & Col. B.
" "	Lower Keuper	Warwick	W. M.

The under-mentioned species have been found in the Permian rocks of Warwickshire :—

Breea eulassoides	Permian	Meriden	W. M.
Caulerpites oblonga	Permian	Meriden	W. M.
" triangularis	Permian	Meriden	W. M.
Coniferous Wood	Permian	Allesley	W. M.
Dasyceps Bucklandi	Permian	Kenilworth and Coventry	W. M.
Labyrinthodon (?) (jaw)	Permian	Coventry	

In the Museum of Practical Geology, London, there are fossils from the Permian of Exhall representing the following genera :— *Calamites*, *Lepidodendron*, *Sternbergia*, and *Strophalosia*.

On the following morning a visit was paid to that grand old pile, Warwick Castle. The Castle stands upon a cliff of Keuper Sandstone, which rises by the side of the Avon and is cut through by the road from the Lodge, along which a section of this important member of the Trias may be observed. Subsequently the

* The Editor is indebted to the courtesy of the Rev. P. B. Brodie for this valuable list of Triassic fossils.

party left Warwick for Wilmcote, where extensive quarries in the Lower Lias, similar to those at Harbury but exposing still lower beds, are situated. In the sections at Wilmcote an exceedingly interesting bed, but wanting at Harbury, is found. This is the "Insect-bed" of the Rev. P. B. Brodie, who has obtained from it a large and valuable collection of insect remains. The Insect-bed is almost the lowest bed of the Lower Lias, and reposes upon the "White Lias" bed at the top of the Rhœtic series. Saurian remains are here frequently met with, and some members of the party obtained good specimens of the jaw of *Ichthyosaurus.* The sections along the railway between Wilmcote and Stratford-on-Avon were next examined. In these exposures the *Cardinia ovalis* bed, the Insect-bed, the "black shales" of the Rhœtic series, and the *Estheria minuta* band of the Keuper marls, are well seen. Under the able guidance of Mr. Brodie, *elytra* of insects were found without much difficulty in the Insect-bed, and some very good specimens were secured. On arriving at Stratford-on-Avon visits were paid to the world-famed "House," the birth-place of Shakespeare, and to the church where the tomb as well as the baptismal register of the great bard are to be found, and the return to Warwick by way of Charlecote Park concluded an excursion abounding in both Geological and Archæological interest.

The Members had been invited by Mr. Brodie to inspect his collection of fossils, and those of the party who remained until the following day and visited Rowington Vicarage were highly gratified with their inspection of Mr. Brodie's museum, which contains, as a portion of a large general collection, the Lower Liassic insect remains which that gentleman has made special objects of search and examination during many years, and which he has very carefully figured and described.

ORDINARY MEETING, November 3rd, 1871.

The Rev. Thomas Wiltshire, M.A., F.G.S., &c., President, in the Chair.

The following Donations were announced :—

"Quarterly Journal of the Geological Society," from that Society.

"Journal of the London Institution," from that Institution.

"Proceedings of the Warwickshire Naturalists' and Archæologists' Field Club, 1870," from that Club.

"Annual Report of the Warwickshire Natural History and Archæological Society, 1870," from that Society.

"Annual Reports of the Royal Cornwall Polytechnic Society" (first and second), from that Society.

"On the Progress of the Geological Survey of Scotland," by A. Geikie, F.R.S., from J. Hopkinson, Esq., F.G.S.

"On the Geology of Edinburgh and its Neighbourhood," an Address to the Geological Section of the British Association, Edinburgh, 1871, by A. Geikie, F.R.S., from J. Hopkinson, Esq., F.G.S.

"On the Nature, Origin, and Geological History of Amber, with an account of the Fossils which it contains," by the Rev. P. B. Brodie, M.A., F.G.S., from the Author.

"Proceedings of the South Wales Institute of Engineers," from that Institute.

The following were elected Members of the Association:—

Thomas Beesley, Esq., F.C.S.; the Rev. Thomas George Bonney, M.A., F.G.S.; Professor James Buckman, F.L.S., F.G.S.; Miss Donagan; Henry Gardner, Esq.; Edward Harris, Esq.; William Harvie, Esq.; Robert Hammond Hicks, Esq.; Charles Hovenden, Esq.; Robert Hudson, Esq., F.R.S., F.L.S., F.G.S.; Charles Lapworth, Esq.; John Comyns Leach, Esq., B.Sc.; Septimus P. Moore, Esq., LL.B., B.Sc., F.G.S.; John East Hunter Peyton, Esq., F.G.S., F.R.A.S.; the Rev. George St. Clair, F.G.S., M.A.I.; and Jeremiah Slade, Esq.

The following Papers were read:—

1. On Old Land Surfaces.

By Professor Morris, F.G.S., Hon. Mem. Geol. Assoc., &c.

(The publication of this Paper is deferred.)

2. Note on a Recent Exposure of the Glacial Drift at Finchley.

By Henry Walker, Esq., F.G.S.

(The facts stated in this brief communication have been embodied in the Paper by the same Author, "On the Glacial Drifts of North London," see next page.)

ORDINARY MEETING, December 1st, 1871.

The Rev. Thomas Wiltshire, M.A., F.G.S., &c., President, in the Chair.

The following Donations were announced :—

"Quarterly Journal of the Geological Society," from that Society.

"List of Members of the Geological Society," from that Society.

"Abstract of the Proceedings of the Geological Society," from that Society.

"Journal of the London Institution," from that Institution.

"Abstract of the Proceedings of the Liverpool Geological Society," from that Society.

The following were elected Members of the Association :—

James Atkinson, Esq.; Arthur Ernest Baldwin, Esq.; Mrs. Annetta A. L. Bowie; Mrs. Elizabeth Catley; Peter Gray, Esq.; German Green, Esq.; Carl Nystromer, Esq.; Owen Rees, Esq., F.G.S.; Edward Frederick Teschemacher, Esq., F.G.S., F.R.G.S.; and Thomas William Tobin, Esq.

The following Paper was read :—

On the Glacial Drifts of North London.*

By Henry Walker, Esq., F.G.S.

The hitherto unmapped deposits of the Glacial Drift at Finchley, Middlesex, have recently been exposed afresh in the railway cutting at the Finchley and Hendon station of the Great Northern line to Edgware. The spot is about six miles from London, and nearly two miles N.W. of the gravel pits in Coalfall Wood, near Muswell Hill, where the first discovery of the Glacial Drift in so southern a part of England was made by Mr. N. T. Wetherell, of Highgate, and laid before the Geological Society of London by Mr. Spencer in the year 1835.

The spot which is now open to inspection was first exposed three years ago, when the railway was in course of formation; but so far as I am aware neither the attention of the public nor of the Geologists' Association was called to the fact at the time, and the com-

* In this Paper has been incorporated Mr. Walker's communication, "On a Recent Exposure of the Glacial Drift at Finchley." See preceding page.

position and contents of the Glacial deposits in this particular area still remain undescribed.

Early in October of the present year, I proceeded by railway from East End to the Finchley and Hendon station, and made the following observations. An open railway cutting is excavated across the plateau which extends from East End to Finchley. At Finchley station and a little beyond, the cutting reaches its greatest depth. In the rear of the passenger platform on the "up" side of the line the slope is being cut back in order to widen the railway, and it is here that the new section is to be seen.

The section extends for about 150 yards on the station side of the railway bridge, at an average depth of about from thirty to thirty-five feet; it is continued beyond the bridge for about the same distance, until the fall in the ground towards Dollis Brook terminates the cutting. The most varied and typical aspects of the beds are on the London side of the bridge. Beyond the bridge the special interest of the section arises from the junction of the London Clay with the Drift beds, which is well exhibited, whilst the London Clay itself at this spot is found to be fossiliferous.

The more varied and characteristic beds opposite the railway station are as follows:—

[SECTION No. 1.]

1.	Vegetable soil	6 inches.
2.	Brown sandy clay, containing Belemnites, *Gryphœa incurva* in abundance, and Chalk *detritus*	14 feet.
3.	Dark blue clay (? Oxford Clay), with abundant Chalk pebbles, and *detritus*, large flints, and Liassic and Oxford Clay fossils, especially *Gryphœa dilatata* (bottom of the bed not seen)	16 feet.

Further on towards the railway bridge the London Clay rises to the surface, and the section presents the following features:—

[SECTION No. 2.]

1.	Vegetable soil	6 inches.
2.	Brown sandy clay, with Belemnites, *Gryphœa incurva* and Chalk *detritus*—base line irregular	20 to 30 feet.

3.	Thin seam of gravel occurring at intervals* .	—
4.	London Clay —chocolate-coloured, largely re-deposited, with potholes filled from the overlying glacial bed†	—

Another characteristic variation in these beds is seen just southwards of No. 1 section. The fifteen feet of blue clay is seen to be interbedded with a thick seam of dry running sand, which lies in a dyke in the clay, and must have been cut transversely upon the formation of the line.

The most remarkable of these deposits is the blue clay, full of chalky *débris* and the characteristic Oxford Clay fossil *Gryphæa dilatata.* Several members of the Geologists' Association who have examined the colour and consistence of this blackish-blue argillaceous mass are struck with its resemblance to the Oxford Clay, as seen *in situ* in its own district. The question has therefore arisen whether the deposit at Finchley has not been drifted *en masse* from the main formation in the Oxford district, bearing with it its own proper fossils.

The probability of the transport of such a mass of rock for a distance of at least forty miles is necessarily to be regarded in connection with the entire bulk of the fragment in question, only a portion of which is exposed at Finchley. I find upon an examination of the district that this blue clay extends continuously from Finchley station to within a quarter of a mile from East End—a distance of at least a mile and a half. It may be seen extending almost without a break in the cutting which lies between these two stations. I have picked up *Gryphæa dilatata* at both extremities of this district. Its depth probably nowhere exceeds twenty feet, but its width is nowhere seen.

It may be well to mention here that such an occurrence as the

* The presence of this gravel is of great significance. It was observed both by Mr. Caleb Evans and Mr. Hicks, of Hendon, before I had satisfied myself as to its existence.

† It will be instructive to compare these sections with the Coalfall Wood Section, furnished by Mr. Wetherell, and published in Mr. Whitaker's Memoirs of Sheet 7 of the Geological Survey, viz.:—

Chalky Boulder Clay, containing rock specimens from all the formations from the Granite to the Chalk inclusive, with abundant Lias and Chalk pebbles, the chalk being in such quantities as to give the whole accumulation a chalky character	15 to 20 feet.
Laminated brick-earth	3 to 4 feet.
Red gravel, about six feet thick, composed of rounded Chalk flints and sand	
London Clay	

transport by natural agency of so enormous a mass of earth from the main formation is not without some remarkable precedents in the history of the Drift deposits of England. I have been referred by Professor Morris to a somewhat similar case which was met with in the excavations for the Great Ponton Tunnel of the Great Northern Railway in Lincolnshire, and which is detailed in a paper by Mr. Morris in the Quarterly Journal of the Geological Society of London, vol. ix., page 419.*

The fossils obtained from this section at Finchley during the last few weeks by myself and other Members of the Association, and now exhibited on the table, represent all the geological formations as far back as the Carboniferous Limestone. They will be found to corroborate a remark recently made to me by Mr. N. T. Wetherell, of Highgate, to the effect that the formations least represented in the Drift near London are the Gault and the London Clay.

The abundance of chalk which is found in the glacial clay at Finchley, and the presence of gravel beneath the glacial clay, can be dwelt upon more satisfactorily under the heads of Classification, Nomenclature, and Correlation, for it is in these connexions that the features in question have their greater significance and interest.

Classification, Nomenclature, and Correlations of the Finchley Drift.

The relations of the Finchley Drift with the marine glacial drifts of other parts of England may now be pointed out. Viewed superficially, the Drift deposits have been found to be so abnormal and perplexing, that they have for a long time been thought to defy any attempts at a satisfactory classification. Until recently, the loose and inexact word Drift, or Boulder Clay, has been the only desig-

* The following is an extract from the paper alluded to :—

"Emerging from the south end of the [Great Ponton] tunnel, which is 880 yards in length, we see the Drift on either side of the cutting buoying up an enormous irregular mass of Oolitic rock, through which the cutting has passed (see fig. 1, s). This mass of rock is 430 feet long, and, at its deepest part, 30 feet thick; it is much broken and disturbed, but the parts retain to some extent their relative position, and belong to the lower portion of the Oolitic beds of the district; the surface is continuous with the hill slope, and is here and there penetrated by intrusive Drift; the lower part is eroded and waterworn. The depth of the underlying Drift exposed at the lowest part between the broken rock and the level of the railroad is about seven feet. Unfortunately the character of the neighbouring surface is so much obscured, that it is difficult to estimate the lateral extent of this great mass of disturbed Oolite. . . ."

Mr. Searles V. Wood, jun., has been good enough to inform me that Mr. Judd, of the Geological Survey, has lately found many such masses in Leicestershire, but of far greater extent, insomuch that he at first took them for outliers of the *parent rock in situ.*

nation available for all the doubtful gravels and clays found at high levels. Fortunately the various deposits thus ambiguously described have at length received a classification and nomenclature. By the labours of a few earnest workers during the past five or six years, a standing geological problem has been successfully attacked, and that mysterious climatic episode which is known as the Glacial Period has been resolved, so far as Eastern and South-eastern England is concerned, into a definite and well-marked series of geological events. It will not be unfair to the several geologists who have contributed to this explication of the Glacial Deposits, to state that the leading part, more especially in the matter of classification and nomenclature, has been taken by Mr. Searles V. Wood, jun., F.G.S.*

The following is Mr. Wood's sequence of the Glacial Beds, as given in the Geological Magazine, for Feb. 1870 and Sept. 1871.

NEWER POST-GLACIAL.	*a.* Ordinary river-gravels and brick-earths without *Cyrena fluminalis*—a series probably extending over considerable time.
OLDER POST-GLACIAL.	*b.* Hessle (Boulder) clay. *c.* Hessle gravel (Kelsea Hill bed) with *Cyrena fluminalis* and the Nar Valley beds. *d.* Gravels mostly occurring on plateaux and on hills;—sporadic accumulations of small extent and at all levels, and connected with the denudation of the glacial beds during their emergence from the great depression.

Here, or more precisely between *c.* and *e.*, intervenes the great denudation and principal unconformity.

* Mr. Wood's papers on the Glacial beds are so comparatively recent, that I find them but little known among the general body of the Geologists' Association; but inasmuch as they comprehend almost all the bibliography of the Glacial beds to which our Finchley Drift is the more nearly related, the following list of Mr. Wood's principal papers is appended, for the information of those who desire to pursue the subject:—

(I.) "The Structure of the Post-Glacial Deposits of the South-east of England." Quart. Journ. Geol. Soc. of London, vol. xxiii., page 394.

(II.) "The Glacial and Post-Glacial Structure of Lincolnshire and South-east Yorkshire." (S. V. Wood, jun., and Rev. J. L. Rome.) Quart. Journ. Geol. Soc., vol. xxiv., page 146.

(III.) "The Pebble-Beds of Middlesex, Essex, and Herts." Quart. Journ. Geol. Soc., vol. xxiv., page 464.

(IV.) "The Relation of the Boulder Clay without Chalk of the North of England, to the Great Chalky Boulder Clay of the South." Quart. Journ. Geol. Soc. vol. xxvi., page 90.

(V.) "The Sequence of the Glacial Beds." Geol. Mag., vol. vii., pp. 17 and 61.

UPPER GLACIAL.	*e.* The Purple (Boulder) Clay of Yorkshire without chalk passing down into *e'.* The Purple (Boulder) Clay *with* chalk, and containing the Bridlington shell-bed. *e''. The Great Chalky (Boulder) Clay.* (Shown at Finchley.)	Both of these have intercalated beds of sand.
MIDDLE GLACIAL.	*f. The Middle Glacial Sand and Gravel with Chalky Boulder Clay in some, though very rare instances, either in or at its base.*—(Shown at Finchley ?)	

A marked unconformity, and a considerable denudation of the beds *g.* and *h.* here intervenes.

LOWER GLACIAL.	*g.* The Contorted Drift of Norfolk and its marl representative. Between this and *h.* there is a very conspicuous denudation and unconformity visible near Hasboro' cliff; but it seems local, and is very different in character and extent to the other unconformities and denudations mentioned. *h.* The Cromer Till, and the Pebbly Sand of Norfolk and Suffolk.

A marked unconformity and denudation here again occurs; the interval of which is, as I *now* think, marked by the Cromer Forest and its associated fresh-water beds.

UPPER CRAG.	*i.* The Chillesford Clay and Sand, forming the upper or marine portion of the Norwich Crag. *k.* The Red Crag, and the lower fluvio-marine portion of the Norwich Crag.

SEARLES V. WOOD, Jun., F.G.S.

The two deposits with which in this classification the Finchley Drift beds are identified are the Great Chalky Boulder Clay and the Middle Glacial Sands and Gravels. Some remarks upon their range through England, and upon their composition as illustrated at Finchley and other sections north of London, may be found useful to those who have not at present studied the subject.

THE GREAT CHALKY BOULDER CLAY OF THE SOUTH EAST OF ENGLAND.—The range of this Upper Glacial of the south-eastern and midland counties seems to be this:—The deposit stretches in an intermittent way from the Thames Valley to Central Lincolnshire, and from the eastern counties of Norfolk and Suffolk to the central counties of England. "Its northern margin," says Mr. Wood, "is cut off by denudation through Lincolnshire, Huntingdon, Northampton, and Lincolnshire; along its south-western margin in Buckinghamshire it is similarly cut off by denudation. . . . . . The contents of a basket of clay taken from either extremity of this area could not be distinguished, although these extremities are 140 miles apart,"* the Chalk *débris* from ice forming a constant feature of the deposit. This Great Chalky Boulder Clay possessed a thickness that seems, before denudation reduced it to all thicknesses, to have generally amounted to 100 feet, and sometimes to have much exceeded this.†

At Finchley Station the Drift lies at a height of 390 feet above Ordnance Datum. At Royston Down, some thirty miles from Finchley, Mr. S. V. Wood has found the Chalky Boulder Clay at an elevation of 550 feet. In Oxfordshire, as Professor Phillip's new work informs us, it is found at 750 feet. It is in the greater elevations of the North of England that we are enabled to estimate the maximum degree of the great Glacial submergence, but these more local particulars are of interest and value to the London geologist, notwithstanding the fact that they are no measure of the depth of the Glacial Sea which was once superincumbent at Finchley.

The derivation of the Chalk *débris* with which the Boulder Clay of Middlesex, Hertfordshire, and Essex, is so abundantly charged, has been matter of conjecture and calculation. Mr. Wood is of opinion that some of it may have come from so near a locality as the East Anglian heights, in Hertfordshire. A glance at the map will show that we have in Hertfordshire some lofty Chalk eminences. Three or four miles from Tring, at Ivinghoe Down, the Chalk range attains an elevation of 900 feet. Insignificant as may seem such hills as these for the supply of the enormous *débris* which has to be accounted for, it will be remembered that to-day we see the East Anglian heights in their denuded and reduced condition, and not as they were before glaciers or icebergs began to waste them, and to distribute the detritus on the glacial sea-bed.

The pebbles of chalk which are found in the glacial clays now exposed at Finchley have already been noticed. These, Mr.

* Quart. Journ. Geol. Soc., vol. xxiii., page 395.

† "Sequence of the Glacial Beds," by Searles V. Wood, Jun., F.G.S. Geol. Mag., vol. vii., page 62.

Wood states, are obviously derived from the hard chalk of Yorkshire or Lincolnshire, termed "rock" by the well borers. The specimens found at Finchley are far different from the soluble chalk of Kent and Surrey.

For the use of those of our Members who may desire to see for themselves some additional instances of the chalky nature of the Middlesex Boulder Clay, I would mention the following places near London where sections are always to be seen—in some cases by the permission of the proprietors:—

Whetstone Gravel Pits.—In rear of the Swan Inn. (A pocket of the chalky clay overlies the gravel.)

Finchley, Totteridge, and Barnet Railway.—Cutting between Finchley and Whetstone: nearer the latter place.*

Manor Brickfield, Finchley.—About a quarter of a mile from the station, London side, N. of the railway.

East End.—The wharf cutting on the Finchley side of the Railway Station.

Finchley Road.—I. Between the East End Station and the Bald-faced Stag Inn, on the right hand side. II. The higher ground in the St. Pancras and Islington Cemetery.

Watford.—St. Stephen's Brickfield, Brickett Wood.

Unlike the next underlying glacial formation, the Great Chalky Boulder Clay is devoid of any molluscan fauna but such as are derived from other formations. This fact, perhaps, is explained by the amount of chalk which the sea must have held in solution, and which may have been inimical to molluscan life.

THE MIDDLE GLACIAL SANDS AND GRAVELS.—In Mr. Wood's Classification, the Middle Glacial Drift lies between the Lower and the Upper Glacial Clay. (The Lower Glacial Clay is not found in the district under consideration.) The magnitude of the Middle Glacial formation may be best illustrated by saying that it extends (mostly covered by the Chalky Boulder Clay) over nearly all the three large counties of Norfolk, Suffolk, and Essex, besides its ramifications over the more central counties of Herts, Bucks, and Leicester. The beds consist of sands and pebbly gravels. The pebbles are flint pebbles, but quartz and quartzites are abundant. The deposit does not seem to rise to an elevation exceeding 420 feet. It occurs at all less elevations down to and below the present

* Mr. Jas. T. B. Ives, F.G.S., one of our Members, called my attention to various newly-opened sections along this line.

sea-level, and attains a thickness of 50 or 60 feet.* Unlike the Upper Glacial, this formation contains a molluscan fauna of its own. The junction of the Chalky Clay (the Upper Glacial) with the Middle Glacial Sands and Gravels indicates an uninterrupted succession of deposits.

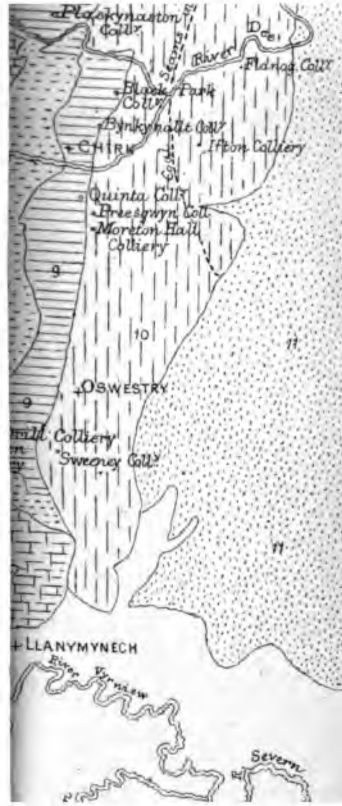
"Does the Middle Glacial occur at Finchley?" is the question which is now raised perhaps for the first time among London geologists. Does the term Middle Glacial, as employed by Mr. Wood, denote those extensive sands and gravels of the Finchley district with which Londoners have so long been familiar? So new is the classification, that it is only upon *prima facie* grounds that I have ventured to arrive, after consultation with other Members of the Association, at an affirmative conclusion.

These *prima facie* grounds are soon stated. Gravel and sand have been seen immediately underlying the Chalky Boulder Clay at the following places:—1. At the Coalfall Wood sections, by Mr. Wetherell (see page 291). 2. At a ballast pit in the Hog-market, between Finchley and Muswell Hill, by Mr. S. V. Wood, jun. (mentioned in a letter to the author of this paper). 3. At Whetstone, at the back of the Swan Inn, where may still be seen a pocket of clay overlying nearly twenty feet of gravel; and, 4, in the section now open at Finchley Station.

Further, the Finchley Boulder Clay has in its vicinity (particularly on its S.W. side towards the river Brent) a number of pits, which show the sands and gravels to be largely developed at a lower horizon. In Ballard's Lane, leading to Hendon, the pits show in some cases nearly thirty feet of sand and gravel; and at the "Green Man," Finchley, are similar beds, which for many years past have yielded drift fossils to Mr. Wetherell, Professor Morris, Mr. Casini of Finchley, and other collectors.† On the table is exhibited the silicified specimen of *Venericardia planicosta* found by Mr. Wetherell in the gravel pits at the Green Man, Finchley.

* "Sequence of the Glacial Beds." Geol. Mag., vol. vii., page 61.

† "The gravel beds of Finchley, which belong to the Drift or Boulder Clay series, have yielded to the research of Mr. N. T. Wetherell, of Highgate, many specimens of flints containing fossils of the Chalk formation—of these the genera *Inoceramus* and *Pecten* are most abundant, associated with which are casts of *Ammonites* and specimens of *Terebratula*, *Rhynchonella*, *Dianchora*, *Lima Hoperi*, *Spondylus spinosus*, and many Echinoderms, as *Micraster*, *Cardiaster* (similar to one from Northfleet), two or three species of *Cidaris*, *Cyphosoma*, *Ananchytes*, and *Galerites*; but with these it is important to notice there are sometimes found silicified specimens of *Venericardia planicosta*, a condition in which these shells are rarely found in their Eocene beds."—Professor MORRIS.—"Note on the Gravel Beds of Finchley, Middlesex," Geol. Mag., vol. v., p. 411.


Plaskynaston Coll^y
River Dee
Fldrlog Coll^y
Black Park Coll^y
Brynkynallt Coll^y
CHIRK
Ifton Colliery
Quinta Coll^y
Preesgwyn Coll
Moreton Hall Colliery
9
10
11
OSWESTRY
Colliery
Sweeney Coll^y
11
LLANYMYNECH
River Vyrniew
Severn

ORDINARY MEETING, January 5th, 1872.

The Rev. Thomas Wiltshire, M.A., F.G.S., President, in the Chair.

The following Donations were announced :—

"Address of the President of the British Association at Edinburgh, 1871," from John Hopkinson, Esq., F.G.S., F.R.M.S.

"Abstract of the Proceedings of the Geological Society," from that Society.

The following were elected Members of the Association :—

Thomas Amey, Esq.; Sir Antonio Brady, J.P., F.G.S.; Norwood Cheesman, Esq.; Henry Lee, Esq., F.L.S., F.G.S.; James Price, Esq.; and George Sedgwick, Esq.

The following Papers were read :—

1.—On the Overlapping of Several Geological Formations on the North Wales Border.

By D. C. Davies, Esq., F.G.S.

The Geological Formations represented on the North Wales Border, consist of the Llandeilo and Bala or Caradoc, Llandovery, Wenlock Shale, Old Red Sandstone, Carboniferous Limestone, Millstone Grit, Coal Measures, Permian, and the various members of the Triassic Group; and it is to the way in which each of these overlaps the one below it, that I would direct attention in this paper.

At a point about midway between the Welsh towns of Llangollen and Corwen, these various formations, as we follow them east and west, approach most nearly their regular sequence, and their conformability to each other, as may be seen in the general section No. 1, which accompanies this paper. But in their continuation southwards the newer formations gradually creep over and cover the older, until at Moelydd, five miles S. W. of Oswestry, the Carboniferous Limestone rests immediately upon the Bala and Caradoc Beds, in the most unconformable manner possible (as shown in Section 3). The overlapping is continued under the alluvium of the valleys of the rivers Vyrniew and Severn to the S.E. of this point, and at Alberbury, the next higher formation, the Coal Measures with its covering of Permian, rests unconformably upon the Silurian traps and schists of the flanks of Breidden Hills and the Long Mountain.

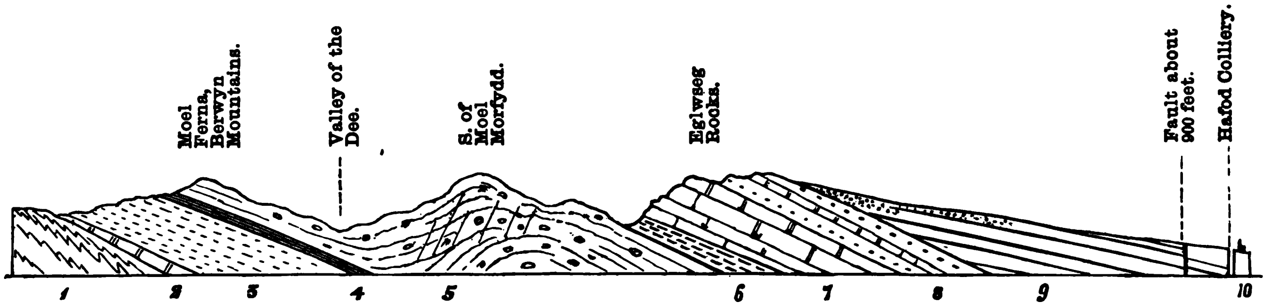
A general idea of the way in which this overlapping takes place may be gained by a reference to the sketch map of the district, which accompanies this paper. It will also be seen that the overlapping increases for the most part as we journey from north to south; though one of the earliest overlaps will prove an exception to this rule. In noticing each formation separately, it will be most convenient to begin with the lower and ascend to the higher strata.

In Glyn Ceiriog (a valley in which I would recommend all lovers of geological explorations to sojourn awhile), we have perhaps the best section of what Professor Sedgwick calls the Bala Beds, elsewhere known more generally as divided into Llandeilo and Caradoc, which is anywhere to be seen. These beds are shown in Section 2. This section extends from Pont y Meibion to Pont dol Wernen, a distance of three and a half miles, as marked upon the map.

In this section we have the main band of Bala Limestone covered by fossiliferous shales, which in their turn are overlaid by the Hirnant Limestone; the whole dipping under the Llandovery beds of the hill Pentre. If from this point we cross the valley and proceed W.N.W. we shall find that the Llandovery Beds of Cefn Coch have crept over and covered the Hirnant Limestone and its underlying shale, and as we proceed westward the main band of the Bala Limestone has also disappeared underneath them, so that it is discovered only by the faintest traces in the romantic gorge where the infant river Ceiriog comes leaping down in a succession of beautiful cascades from the moorland of the Berwyn Mountains. This covering is shown in the left of Section 1. This Limestone emerges again as we reach the neighbourhood of Llandrillo (to the west of the section). The beds above, including the Hirnant Limestone, remain covered along the eastern sides of the Berwyn Mountains; but we ascertain the continuation of this limestone under the Llandovery and Wenlock Beds of those mountains, by its appear anceon their western side in the valley of the Hirnant, near Bala, where the veteran Professor Sedgwick first made its acquaintance.

This overlap of the Bala by the Llandovery Beds is the exception to the general way in which the overlapping increases towards *the south*, to which I just now referred.

SECTION I.—Illustrative of the Sequence of the different Geological Formations between a point East of Llandrillo and Hafod y bwch Colliery, Ruabon, North Wales.



1. Llandeilo Beds with Greenstones and Porphyries.
2. Place of the Bala Limestone, Shales, and Hirnant Limestone.
3. Llandovery Beds very fossiliferous.
4. Tarannon Shale.
5. Wenlock Shale with a capping of Ludlow Beds in places.
6. Old Red Sandstone.
7. Carboniferous Limestone.
8. Yoredale Rocks and Millstone Grit.
9. Coal Measures.
10. Permian.

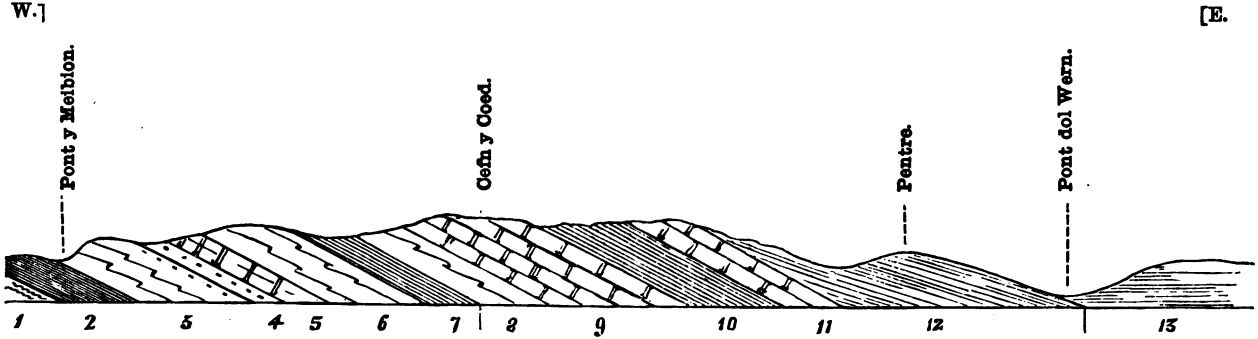
Horizontal Scale ⅜ of an inch to a mile.

NOTE.—The Wenlock beds are for the most part unfossiliferous, owing to their arenaceous character, but there are places where they yield good specimens of the Encrinite *Actinocrinus pulcher*. The Upper Limestones of the Eglwseg Rocks are very rich in Corals.

The next overlap is that of the Llandovery by the Wenlock Beds. Along the line of Section 1, the Llandovery Beds appear in great force. They amount to two or three thousand feet of strata, and form a series of escarpments, with intervening ledges of green sward. Mr. Parrot, of Llantysilio, has given great attention to these beds. He has obtained from them a very complete and beautiful series of Trilobites and other fossils. He divides them into four distinct zones of life, each of which he deems to be characterized by the preponderance of certain organisms. The uppermost of these beds or zones is capped by the Tarannon Shale, an instructive section of which may be seen in a gorge a little to the N.W. of Moel Ferna, and the whole of them dip under the great mass of Wenlock Shale. If from the junction of these three, as shown on the line of Section 1, we proceed eastward, we shall find the Wenlock Shale covering, first, the Tarannon Shale, then, one by one the Upper Llandovery Beds, until when we have reached Cefn Coch, we find that by a sudden sweep to the south of the Wenlock Beds, all the zones of Llandovery life are covered, except the lowest, which is characterized by a profusion of the remains of zoophytic life. This, too, is almost completely overlapped, as we descend to the New Inn in Glyn Ceiriog, at which point the Wenlock Beds almost touch those of the Bala Group. A little bend, however, in the outcrop of the former, allows the lowest Llandovery Beds to be seen in the hill Pentre (seen on the right of Section 2), and then the great mass of the Wenlock Shale comes sweeping around, and hides them altogether from sight.

The next overlap, in ascending order, which I shall notice, is that of the Old Red Sandstone by the Carboniferous Limestone. The Old Red Sandstone is not extensively developed along the North Wales Border. It attains its greatest thickness about three miles north of the town of Llangollen, as shown on the map near the line of Section 1. At this point it consists of Conglomerates, Red Marls, and Grey, and Yellow Sandstones. Northwards it is frequently seen cropping out from under the Carboniferous Limestone, though with diminished thickness ; but south of this point the Limestone quickly covers the whole of the beds. Its continuation under the Limestone is, however, indicated by a bed of hard red marl, which in places is seen lying between the Limestone and the underlying Silurian strata. Traces of this bed may *be seen* in the little valley of the Morda above the Lawnt, three

SECTION II.—Strata in Glyn Ceiriog, North Wales.



Llandeilo Beds.
1. Compact Greenstone.
2. Dark Pyritous Shales.
3. Porphyritic Beds.
4. Sandstones and Shales.
5. Dark Limestone.
6. Massive Felstone and Ashy Beds.
7. Shales and Slaty Beds.

Bala Beds.
8. Ashy Beds.
9. Bala Limestone.
10. Fossiliferous Shales.
11. Hirnant Limestone.

12. Llandovery Beds (very fossiliferous).
13. Wenlock Shale.

Horizontal Scale 2 inches to a mile.

NOTE.—The Porphyritic Beds No. 3 are very remarkable, and some of them beautiful stratified beds. The Limestone No. 5 is that which was originally described by Professor Sedgwick as "the dark Limestone of the River Deirew." I do not think, however, that the Professor recognised it as lower in the series than the Bala Limestone. I take it to be the equivalent of the Llandeilo Limestone.

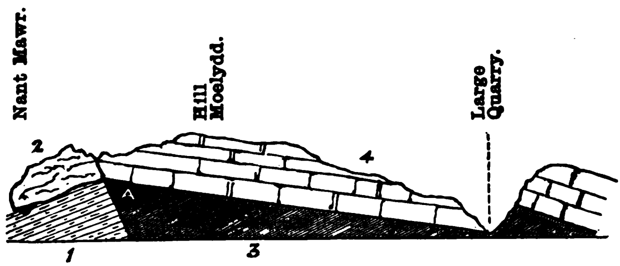
miles W.N.W. of Oswestry; and at Llanymynech, the southernmost termination of the Limestone, at least on the surface of the land.

A little to the east of this thickest development of the Old Red Sandstone, and above the grand escarpment known as Eglwseg Rocks, the Carboniferous Limestone attains to the greatest thickness reached by it on the North Wales Border. I am strongly of opinion that beds are shown here in its uppermost portion which are not seen to the south of this spot, but as I am not able at present to speak definitely on this point, I will proceed to notice the next well-defined overlap, which is that of the Millstone Grit by the Coal Measures. The general character of the Millstone Grit, as it is seen along the North Wales Border, is, in ascending order, first a series of purple and reddish-yellow flags and sandstones, the latter often conglomerate with large pebbles. Secondly, a series of beds, which, in the southern portion of the district, are made up of calcareous sandstones, with thin intercalated beds of limestone, which beds, in their extension northwards become more decidedly calcareous, until, in the vicinity of the town of Mold, they form massive beds of limestone, which are worked for agricultural lime. And thirdly, a series of massive sandstones, pinky white in colour, which contain pebble conglomerates. The beds below these sandstones resemble most nearly, perhaps, the Yoredale Rocks of the North of England. About three miles east of Llangollen, and a little to the south of the line of Section 1, these sandstone beds are capped by massive beds of hard, white, brecciated sandstones, with intercalated shales. These sandstones bear the strongest resemblance to the true Millstone Grit of the North of England. Northwards these beds continue to be well exhibited, but southwards they are almost immediately covered by the Coal Measures, which gradually also creep over the shales below, so that at Sweeney, near the southern disappearance of the Millstone Grit, the Coal Measures rest immediately upon the pinky white sandstones mentioned above.

We now ascend to the upper portions of the Coal Measures. This formation attains its greatest thickness between Ruabon and Wrexham, near the eastern extremity of Section 1. At this point there is a covering of Permian 420 feet, or thereabouts, in thickness. From the base of this "Red Ground," as it is locally called, to a coal known as the "Dirty," or "Drowsel Coal," there is a

SECTION III.—Illustrative of the Relative Position of the Carboniferous Limestone to the Llandeilo and Bala Beds at Moelydd, 5 miles S. W. of Oswestry, showing the absence of all the intervening Strata, as seen in Section I.

W.] [E.



Llandeilo Beds. 1. Shales.
2. Felspathic Trap and Greenstone, with Crystals of Sulphate of Iron.

3. Bala Schists with a dark coloured very fossiliferous bed A in their upper portion.
4. Carboniferous Limestone.

Length of Section 1¼ miles.

succession of strata, including sixteen seams of coal, and a freestone rock, well known in the neighbourhood as the Cefn Rock, amounting altogether to 801 feet in thickness. I have been at great pains to correlate the principal coal seams in the district, and as the result of my enquiry I take the "Rover" and "Black Shale Coal" of the Drill pits, one mile south of Oswestry, as the equivalent of this Dirty Coal in the neighbourhood of Ruabon. Now, at this southern extremity of the main coalfield, the Permian has covered the edges of all the intervening 711 feet of strata, leaving only about 90 feet between the base of the Red Ground and the Rover Coal. This 90 feet of strata corresponds most nearly in its character with the beds lying immediately above the Dirty Coal at Hafod y Bwch.

It will also be noticed how the Permian gradually covers the surface of the Coal Measures in their continuation southwards, so that at Sweeney it rests immediately upon the Millstone Grit, and a little further south it has covered this and touches the Carboniferous Limestone.

The Permian Beds are represented in the district by the "Red Ground," of which I have spoken, and which ranges in thickness from 420 feet at Hafod y Bwch to 360 at Drill, south of Oswestry. But at Ifton, which is marked darker on the map, these beds are surmounted by a succession of beds amounting in thickness to about 300 feet, which consist of sandstones, shales, clays, irregular layers of concretionary limestones, and three seams of coal, the middle one of which is worked. The outcrop of these seams is to be seen in the picturesque escarpment known as Coed y rallt rock, near the junction of the rivers Ceiriog and Dee. Excepting in a limited area of about seven miles by three, these beds are not seen. Southwards they seem to have suffered denudation, eastwards they dip under the New Red Sandstone, northwards, at a short distance, there is a trace of them, but the Triassic beds extend round to the west as we advance northwards, and rest upon the deep red coloured beds of the Permian, and when we pass to the north of the map to the vicinity of Chester, Parkgate, and Neston, these Triassic beds seem to rest immediately upon the Coal Measures.

I have thus traced six well-marked overlaps. There are many faults in the district which affect the surface relation of the different formations locally, but which do not affect the general question. These I have not thought it necessary to notice; indeed, they would require a paper confined to themselves. I would therefore proceed to make a few observations which seem to be suggested by the subject we have been considering, and—

First—Conformability of strata at any given point does not necessarily imply that we have at that point the unbroken order, and full sequence of that strata. For example, in the west of Section 1, the Llandovery Beds seem, at the surface point of contact, to rest conformably upon the Bala Beds, and if the latter were not developed elsewhere, we should conclude we had the entire series; but when we refer to Section 2, we see that the whole of the upper portion of those beds, amounting to a thousand feet or more, have been covered, and lie hidden at some distance beneath the Llandovery. Again, it would be difficult, if not impossible, to trace any unconformability between the Permian and the underlying Coal Measures at Drill, south of Oswestry; yet, as we have seen, there is an absence at that point of 711 feet of coal strata, which are gradually developed as we proceed northwards. The other overlaps lead to the same inference.

Secondly, the difficult question arises, to what cause, or combination of causes, is the absence of the intervening strata at the points I have mentioned due? Were they never deposited? or were they deposited and then denuded before the overlying formation was deposited? A vast field of enquiry is opened out by these questions. We too often think of a formation or group of strata as deposited quietly and without disturbing influences, and then after the work of deposition has been completed, the work of denudation has commenced, whereas nothing can be further from the truth. We have many evidences in each of the formations I have named, that the work of denudation was going on in one part of a large area, whilst the work of deposition was going on in another, materials deposited and then re-distributed. Nor does the work of deposition seem to have proceeded without disturbance. There are faults belonging to and confined to the period of each formation, there were elevations and subsidences of the land which may have prevented the deposition of material in one locality, and aided in the destruction of deposited matter in another.

Nor must we forget that the original conformation of the surface when a new formation began to be deposited, would affect the whole question. Take the Coal Measures, we can conceive how these deposits would abut against rocks of Millstone Grit here, and cover great flats of sandy land there, and again creep up and cover gently shelving shores, and wind up sinuous valleys. How, while the closest conformability would thus ensue in one place, the greatest unconformability would be taking place at another. We are thus taught that the value of conformability or unconformability of strata alone as an evidence of the true sequence of geological formations is very much lessened; since, as we have seen, no geological formation has had an even underlying surface to begin with; or has been undisturbed in the course of its deposition; or has had an equal area for its deposition during each part of the immensely prolonged period of its growth. These inferences, may sound in some ears, as geological truisms; but, for all that, I fear they are too much forgotten in geological theorizing.

Thirdly—in the apparently indiscriminate way in which the newer formations rest upon the older ones, as shown on the map, we have an indication both of the extent and age of the denudations which have taken place in the past. Look at the portions which represent the Wenlock Shale, and say if they do not seem to indicate an extension at one time of that formation over all the intervening area. If this were so, then the mighty denudation by which the thousands of feet of strata were stripped off the Bala Beds, and even these stripped off their lower portion, the Llandeilo, took place before the deposition of the Carboniferous Limestone. For, you observe, the latter covers all alike. Take again the fault at the extreme east of the Section 1, elevate the beds to the right of it to their true place, 900 feet or so, and you will at once see how the upper portion of the Coal Measures, with its covering of Permian, must have extended westwards over the Lower Coal Measures, Millstone Grit, Carboniferous Limestone, and it may be not have thinned out before they reached the Wenlock Shale and Bala Beds, just as the same Upper Coal Measures do now at Alberbury and Westbury, in the south-east of the map, lie immediately upon those formations.

We may ask—to what purpose was this waste? We observe, in our researches into the past, a profusion of life, and a prodigal display of wealth, which seem only to have been made to be remorselessly washed away and destroyed; like myriad germs of beings which never attain fulness of life, like millions of rays of light and heat which seem lost in empty space, and never kindle upon any world; but if we ask the question in a profoundly philosophic spirit, each newer formation will be to us an answer. We shall discern a spirit of economy in the midst of the apparent waste. We shall see that the wise Power which makes the dead leaves of Autumn minister to the fresh life of Spring, has swept away old lands only to lay the foundations of new, which should contain advanced life, truer beauty, ever-increasing thought, and a power to discern in the rise and wreck of lands, in the birth and decay of life, in the growth and fall of nations, indications of a

Grand far-off event,
To which the whole Creation moves.

2. Report of the Proceedings of the Geological Section of the British Association at Edinburgh, 1871.*

By John Hopkinson, Esq., F.G.S., F.R.M.S.

(*Abridged.*)

The proceedings of the Geological Section commenced on Thursday, the 3rd of August, with an address by the President, Professor Geikie, F.R.S., on the Geology of Edinburgh and its Neighbourhood, of which the following is a brief summary.

From the battlements of Edinburgh Castle we may obtain a clear view of the country for many miles around. To the south-east the horizon is bounded by a range of high ground, a portion of the Silurian uplands of the south of Scotland, forming the Lammermuir and Moorfoot hills. These Silurian rocks, the oldest strata in the district, are bounded on their north-west side by a long fault, by which the Carboniferous rocks, forming the plain of Mid-lothian, are brought down against the hills. On the south, the Pentland hills, consisting chiefly of rocks of Old Red Sandstone age, rise along an anticlinal axis, which is prolonged through the Braid hills, past the Castle Rock, and as far as the opposite shores of Fife. From this axis the rocks dip away on either side. On the east they dip eastward, as shown by the escarpments of Salisbury Crag, Arthur's Seat, and Calton Hill, and on the west the escarpment of Corstophine Hill points out the westward dip.

But this fundamental structure is somewhat complicated by a long and powerful fault which flanks the axis on its south-western side; throwing out part of the Lower Carboniferous rocks; bringing the Carboniferous Limestone, in some places, close against the Lower Old Red Sandstone; tilting the strata; and on its eastern side throwing on end the Limestone series, and in some places even bending it back into a reversed dip.

Another remarkable feature is that on the west side of the Pentland ridge the Carboniferous series abounds in contemporaneous volcanic rocks, while on the east side, beyond Edinburgh and

* This report was furnished by Mr Hopkinson as one of the deputation representing the Geologists' Association at the Edinburgh Meeting of the British Association. In the report, as read, abstracts of the different papers communicated to Sect. C., and of the discussions which ensued, were given. In this abridgement a few of the papers are noticed at full length; of some the titles only are given; and the reports of the discussions are entirely omitted.—Ed.

Arthur's Seat, such rocks are entirely absent for a considerable distance.

These igneous rocks form one of the most characteristic features of the geology of Edinburgh. The rocks which form the main mass of the Pentland hills are of volcanic origin. Here, in the time of the Lower Old Red Sandstone, volcanos poured out great sheets of porphyrite and showers of tuff. Again, early in the Carboniferous period, the volcano of Arthur's Seat and Calton Hill threw out tiny flows of basalt and porphyrite, and showers of ashes; and from this time till nearly the close of the Carboniferous Limestone series the district to the west of Edinburgh was dotted over with small cones, usually of tuff, but sometimes emitting limited currents of different basalt rocks. To the north and east also, during this period, volcanos were active.

Before the next outbreak of volcanic action in this neighbourhood more than 3000 feet of strata had been removed by denudation from the Pentland anticlinal. A new focus of eruption was then formed, and from it were ejected the basalts and coarse agglomerates of the summit and higher ridges of Arthur's Seat. This eruption most probably took place in the Permian period.

There remains for notice but one other period of volcanic action. A series of basalt dykes, running east and west, rise indifferently through any part of the other rocks, aqueous or igneous. These dykes belong to an extensive series, which, dating from Miocene times, form a striking memorial of the vigour of volcanic action during the last period of its manifestation in this country.

The craggy heights of Edinburgh, though thus composed of igneous rocks, are not due to igneous upheaval, or to the outlines assumed by the various volcanic products. The rocks which, from their hardness, have presented the greatest resistance to erosion, alone rise into eminences. The hills around Edinburgh have a distinctively ice-worn aspect. Each of them is, in fact, a great *roche moutonnée* left in the path of the vast ice-sheet which passed across the land. That this ice passed over even the highest hills is proved by the striæ on the summits of the Pentland hills; and that it came from the Highlands is indicated by the pebbles of granite, gneiss, schist, and quartz rock, occurring in the boulder clay which it produced. But it is by no means to the action of ice alone that the present form of the ground is due. Denuding agencies have apparently been at work from the earliest times. Here, as elsewhere in this country, we find that "the present landscape (I quote the concluding words of Professor Geikie) has resulted from a long course of sculpturing, and that how much soever that process may have been accelerated or retarded by underground movements, it is to the slow but irresistible action of rain and frost, springs, ice, and the sea, that out of the various geological formations among which Edinburgh lies, her picturesque outline of hill and valley crag and ravine, has, step by step, been carved."

At the conclusion of this address Mr. James Thompson read a paper on the Age of the Stratified Rocks of Isla, the result of a most careful investigation of the metamorphic Silurian and pre-Silurian rocks, the base of which the author considered identical with the Fundamental Gneiss of the Scottish Highlands.

Dr. Bryce read the third report of the Committee on Earthquakes in Scotland.

Mr. Henry Woodward then read his report on the Structure and Classification of the Fossil Crustacea. During the past year 21 new species had been described; 4 being Decapods; 1, an Amphipod; 2, Isopods; 1, a Merostomate; and 13, Phyllopods. A new Isopod, *Palæga Carteri*, had been found in three localities in the Cretaceous rocks of England, and also in the Chalk of Upper Silesia, and in the Miocene of Turin. Referring to the Trilobite leg controversy, Mr. Woodward showed that if legs were essential to Trilobites, as he and Mr. Billings believed, the Isopodous type would be carried back in time to our earliest Cambrian rocks.

A discussion on *Dictyoxylon*, a genus of Coal Measure plants, followed. A new species had been found near Burntisland by Mr. G. J. Grieve; and Prof. W. C. Williamson, F.R.S., here described its structure, giving it the name of *Dictyoxylon Grievi*.

Mr. Carruthers, F.R.S., then read a paper by Mr. Grieve on the Position of the Organic Remains with which this species occurs. Mr. Grieve's attention was first directed to the specimens by observing on the shore large masses of limestone which had been polished by drifting sand. These were found to be filled with coal-plants, and the limestone was traced to the cliffs above, where it appeared to be intercalated in a mass of volcanic products.

Mr. Carruthers, in a paper by himself on the Vegetable Contents of these masses of limestone, said that he considered that the plant remains had been enclosed in a peaty condition, from the surface bed on which they were growing when the volcanic ash was ejected, the lime abounding in the bed having subsequently calcified them, preserving all the details of their structure.

FRIDAY, AUG. 4.—Mr. Pengelly, F.R.S., read the seventh report on the Exploration of Kent's Cavern, Devonshire. After some introductory remarks on the history of the cavern he stated the usual section to be:—1. Black mould, containing objects of Romano-British and pre-Roman times, with some of recent date, and also remains of recent animals. 2. Granular stalagmite, containing remains of extinct animals. In this, the upper stalagmitic floor of the cave, a human jaw has also been found. 3. Red cave-earth, enclosing angular fragments of limestone, with flint implements and remains of extinct animals. 4. Crystalline stalagmite, forming a second stalagmitic floor; and below this, in certain parts only, a breccia formed from distant rocks. In these, remains of bear only have been found.

Since the last report given in by the committee they had been exploring in Smerdun's Passage, where, since the end of August, 1870, 2200 teeth had been found, and also a large number of bones, portions of bones, and fragments of antlers. The teeth belonged to different animals in the following proportions:—hyæna, 335 per thousand; horse, 295; rhinoceros, 161; Irish elk, 55; ox, 35; deer, 27; badger, 22; elephant, 20; bear, 18; fox, 12; lion, 6; reindeer, 5; wolf, 4; bat, 2; rabbit, 1; dog (?), less than 1. Other parts of the cave had also been explored.

The Rev. W. S. Symonds then gave an account of a Hyæna's Den on the Great Doward, Whitchurch, Herefordshire, usually known as King Arthur's Cave. The situation of the cave, in its relation to the geology and physical geography of the surrounding district, was first pointed out, and the following section of the cave deposits given:—1. Fallen *débris*, with human bones and pottery, probably Roman. 2. Cave-earth, with flint flakes and chips, and remains, mostly teeth, of the cave lion, cave bear, hyæna, mammoth, long-haired rhinoceros, and fossil horse. 3. Stratified sand and silt, the remains of an old river bed, with rolled pebbles derived from the Silurian rocks of Rhayader and Builth. 4. A thick floor of stalagmite. 5. A second deposit of cave-earth, separated every few feet by thin layers of stalagmite, and containing remains of the cave lion, hyæna, rhinoceros, mammoth, Irish elk, horse, bison, and reindeer, with a few flint flakes.

The author inferred—1st, that King Arthur's Cave was once a deep fissure in the Mountain Limestone, and was gradually silted up by the lower cave earth, and that during this period it was a hyæna's den, occasionally haunted by man. 2nd, that the stratified sand and gravel was washed into the cave by an ancient stream which flowed in the same direction as the existing River Wye, but 300 feet above its present level; the Mountain Limestone gorge, through which it flows, having thus been excavated to its present level during the human period.

Mr. L. C. Miall described the results of some further Experiments on the Contortion of Rocks. He had subjected various rocks to forces of low intensity, but of long continuance. Mountain and magnesian limestone could be bent round to almost any angle, flagstone was moderately flexible, but slate could not be permanently bent, cleaving rather than bending. Some cases of superficial contortions of rocks were then noticed, and Mr. Miall showed that a large amount of contortion at the surface did not necessarily imply any alteration at great depths, and that faults frequently disappear as we pass down.

A paper by Prof. Hull and Mr. W. A. Trail on the Relative Ages of the Granitic, Plutonic, and Volcanic Rocks of the Mourne Mountains, Down, Ireland, was then read. The authors referred to the presence of two varieties of granite, differing in composition, mode of formation, and relative age; the soda granite of Slieve Croob being of metamorphic origin, and the potash granite of Mourne being eruptive. The granite of Mourne was considered to be of Mesozoic, and the granite of Slieve Croob of Palæozoic age.

The meeting concluded with a paper by Mr. R. Daintree, on the general Geology of Queensland. The author showed the dependence of metalliferous lodes in this area on intrusions of trap, though in the trap dykes themselves no minerals occur.

Saturday, Aug. 5.—The Rev. Dr. Hume read a paper on the Coal Beds of Panama, in reference mainly to their economic importance.

Dr. Moffat read a paper on the relation between Geological Systems and Endemic Disease.

The Rev. J. F. Blake contributed a paper on the Yorkshire Lias, and the Distribution of its Ammonites. He recognised 15

Ammonite Zones, described their lithological character and position, and gave a list of the Ammonites occurring in each zone.

An account, by Mr. Henry Woodward, of some Relics of the Carboniferous and other Old Land-Surfaces, previously communicated to the Geologists' Association,* was then read, and the section adjourned at one o'clock.

Prof. Geikie then conducted the members over Arthur's Seat.

In the ascent, the different rocks of which the hill is composed were described by Mr. Geikie. The lowest and oldest rocks were seen to consist of calciferous sandstone and shales, pierced by intrusive sheets of basalt, and containing, in their upper portions, a series of contemporaneous volcanic rocks. The bottom bed of this series consists of a black, compact, dolerite or basalt, and is succeeded by red shales, sandstone, and limestone. Then comes a greenish trap tuff, containing, near St. Anthony's Chapel, plant remains and teeth of the old Carboniferous fishes. Over this tuff lies a group of basalt beds, apparently the same as the lowest beds of Calton Hill; and lastly, the porphyrites, forming the eastern part of Arthur's Seat, are seen. These rocks all dip eastwards, presenting their denuded edges to the west. In this direction the Castle Rock, like a plug of basalt, is seen. This rock may mark the centre of an old volcano, Calton Hill and Arthur's Seat being fragments of the cone; the strata on the east side of the Castle Rock dipping towards the east, and the strata on the west side dipping west. Still ascending, near the summit of the hill a coarse trappean agglomerate of Permian age, consisting of fragments of the rocks below embedded in a compact felspathic base, is seen to overlie unconformably the older Carboniferous rocks. The summit consists of basalt, a column of which fills up the orifice of this more recent Permian volcano.

These later rocks of Arthur's Seat, though now confined to the summit, must at one time have extended over a great part of the surrounding country. They are, said Prof. Geikie, *merely fragments* of strata, once greatly thicker and more extensive than now.

Descending the hill on the south side, the Queen's Drive was reached, and in returning to Edinburgh the well-known ice-grooved rock was examined, and near it, another rock, marked by the grinding of the rock upon itself, or rather the grinding together of two

* *See* Proc. Geol. Assoc., Vol. II., page 231.

surfaces of rock, producing the appearance called slikensides, allowed these two forms of striation to be readily compared.

MONDAY, AUG. 7.—Mr. James Thompson presented his report on Sections of Fossil Corals. He briefly pointed out and illustrated by a series of beautiful photographic plates, the structural characters and development of the Carboniferous corals; and he then explained the method by which the sections were prepared, and described a new process whereby he transferred the photographs to copper plates, representing the minute structure of the most delicate parts.

Sir Richard Griffith, Bart., F.R.S., gave an account of the Boulder Drift, Esker Hills, and Erratic Blocks of Ireland. He described the boulder-drift as consisting of sandy clay, containing numerous stones and boulders, and he considered it to have been suddenly deposited by a great torrent. The esker hills were formed after the drift by a shallow sea acting upon it. These hills are in the form of long ridges which traverse the centre of Ireland from east to west, taking a north-westerly direction when they reach the valley of the Shannon. They rise from 20 to 60 feet above the boulder-drift, and from their extent and unbroken continuity form a remarkable feature in the landscape. The erratic blocks, which are totally unconnected with the drifts, are all angular, and being composed of the porphyritic granite of Galway Bay, must have been transported by a current from the north-west.

Dr. Murie read a paper on the Systematic Position of *Sivatherium giganteum*, an extinct mammal (of Miocene age), from the Sewalic range of the Himalayas. The author considered the *Sivatherium* to have been a ruminant, in some respects deer-like, in others more like the antelope, but more nearly allied to the prongbuck, the saiga, and the bramatherium, and combining in itself some of the characteristic features of each of these animals, having had deciduous hollow horns like the prongbuck, which it most resembles; facial bones like those of the saiga; and four horns as in the bramatherium, with a similar dentition.

Mr. Boyd Dawkins, F.R.S., described the relation of the Quaternary Mammalia to the Glacial Period, dividing the animals in the order of their appearance into five distinct groups; the first (or most recent) of which comprises the animals now living in the temperate regions of Europe and America; the second, or

Arctic group, those now confined to cold climates; the third, those now only found in hot regions; and the fourth and fifth, of extinct forms. The fifth group shows that there is no very decided break between the Quaternary and the Pliocene.

A paper by Messrs. Lapworth and Wilson, on the Silurian Rocks of the Counties of Roxburgh and Selkirk, was then read by Mr. Lapworth. The authors showed that these rocks, which had previously been almost entirely unexamined, were capable of division into well defined and well-marked groups. They had discovered a large number of fossils, which had been obtained from all parts of the district, and from the lowest to the highest bed examined.

The subdivisions of the strata which the authors adopt are as follows:—1. The Hawick rocks, at the base, consisting of arenaceous grey and purple sandstone and schist, with *Protovirgularia* and supposed worm-tracks. 2. The Selkirk beds, comprising a great thickness of fine-grained grits, flags, and shales, and containing *Protovirgularia*, *Protichnites*, Annelides, and Phyllopods. 3. The Moffat series, principally consisting of beds of greywacké with intercalated shales, and with a band of anthracitic shale, at its summit, well known for the number of Graptolites it contains. 4. The Gala group, consisting of grits, sandstones, shales, and conglomerates, from which a considerable number of fossils, distinct from those of the Moffat series, have been obtained. 5. The Riccarton beds, consisting of grits and shales with little bands of carbonaceous schist, and containing Graptolites and other fossils of Upper Silurian age.

Mr. Lapworth then enumerated the Graptolites of the Gala Group, describing two new species—*Graptolithus socialis* and *Retiolites obesus.*

Mr. D. J. Brown read a paper on the Silurian Rocks of the South of Scotland, in which he endeavoured to show that there is a line of unconformability between the Moffat rocks and the overlying beds, the chief evidence adduced in support of this view being the presence of a coarse conglomerate, apparently forming the base of the upper rocks, and containing fragments of shale yielding Graptolites of Moffat age.

Mr. Brown then read two papers on the Geology of the Pentland Hills. In the first, by himself, it was stated that in the Pentlands both the Wenlock and the Ludlow rocks are represented, and that the Lower Old Red Sandstone, hitherto supposed to form a considerable portion of the Pentland hills, is wanting; also that the Lesmahago beds form a higher portion of the Ludlow Rocks than any found in the Pentlands; and in the other, by Mr. Henderson, that the Pentland felstones cut through, indurate, and enclose, angular fragments of rocks belonging to the upper portion of the Lower Carboniferous series, and that the so-called Old Red conglomerates contain limestone pebbles enclosing Carboniferous fossils.

TUESDAY, AUG. 8.—Professor Duncan, F.R.S., read his third report on the British Fossil Corals. Commencing with the encouraging remark that the classification of the Palæozoic corals "is in a condition of profound confusion," he proceeded to show how Ludwig, of Darmstadt, had added to the confusion by entirely dispensing with the received classification, altering the established generic and specific names *ad libitum*, and designating well-known genera by such euphonious names as, for instance, *Astrophlæothylacus*, *Tænio-chartodiscus*, *Liophlæocyathus*, and *Ptychophlæolopas!* Prof. Duncan, in this report, dealt with the classification of these corals in a less summary manner. In considering the alliances between the Neozoic and Palæozoic coral-faunas, he stated that the Lower Cretaceous and Neocomian corals appear to connect the oldest and the newest faunas. The transition from the Cretaceous to the existing corals is gradual, and the break between the Cretaceous and Palæozoic coral-faunas is not so decided as was formerly supposed; the Rugosa, for instance, being now known to be not entirely confined to Palæozoic strata. New forms, which fill up the spaces in the received classification, are constantly being met with as we study the coral-faunas backwards in time. A great number of existing species, also, are now known to have lived in the Pliocene, and not a few in the Miocene.

Professor Geikie read a report on the progress of the Geological Survey in Scotland during the last four years. The Lower Silurian rocks of the Southern Uplands, the Old Red Sandstone between Edinburgh and the south of Ayrshire, the Carboniferous rocks of the south of Scotland, and the Permian basins of Ayrshire and Thornhill, had occupied the attention of the Survey during this period. The superficial accumulations are now mapped in as great detail as the rocks underneath, and plans are being prepared with a view to issue maps of the surface geology.

Mr. Woodward recorded the discovery, in the Ironstone of the Dudley coal-field, of a specimen of the *Curculioides Prestvicii* of Buckland, which proves that this species was one of the "false-scorpions," and not a Coleopterous insect as formerly supposed. He proposed the name *Eophrynus* for this new genus of Arachnida.

Mr. Stuart Menteath read a paper on the Origin of Volcanos, in which he attributed the force of volcanic action to solar energy stored up in rocks by buried organic matter, volcanos, like steam-engines, being worked by "the light of other days."

A specimen of *Conocoryphe Lyelli* from the Lower Cambrian rocks of St. David's, South Wales—one of the earliest forms of Tribolites—was then exhibited by Prof. Harkness, F.R.S.; a number of fossils from the Durine Limestone of Sutherlandshire, by Dr. Bryce; a new Onchus spine from the Lower Old Red Sandstone of Hay, Breconshire, by the Rev. W. S. Symonds; and two specimens of the so-called Hyoid Plate of the *Astereolepis* of the Old Red Sandstone, by Mr. John Miller, who stated that these specimens showed clearly that what had hitherto been supposed to be the *hyoid* plate was in reality the *dorsal* plate.

Prof. Traquair then gave an account of some Recent Additions to the Fossil Vertebrate Fauna of Burdiehouse, near Edinburgh; and Mr. Peach, an account of other fossils from the Carboniferous rocks in the neighbourhood of Edinburgh, exhibiting a beautiful specimen of *Antholithes Pitcarniæ*, with its fruit (*Cardiocarpon*) attached.

Mr. D. Grieve, in a note on the Fossiliferous Strata of Lochend, near Edinburgh, showed that the Burdiehouse Carboniferous rocks extended to this locality—the presence of the Carboniferous rocks so far to the eastwards not having been previously known.

Mr. Milne-Home brought forward a scheme for the conservation of remarkable Boulders in Scotland, and for the indication of their position on maps.

The Rev. John Gunn contributed a paper on the Agency of alternate Elevation and Subsidence of the Land in the Formation of Boulder Clays and Glaciers, and on the Excavation of Valleys and Bays. He considered that the glacial epoch was due to the *elevation of* mountain ranges; that the boulder-clays were formed in a temperate rather than in a glacial period; and that valleys and gorges were frequently due to the action of shallow seas.

Mr. J. E. Taylor read a paper on the later Crag Deposits of Norfolk and Suffolk, in which he showed that the upper part of the Reg Crag was very similar to the Chillesford beds, and had many species in common with them.

L'Abbé Richard then read a paper in French on "Hydro-geology." He could detect, he said, by a law only known to himself, the existence of hidden springs. He cited some of the results he had obtained by the knowledge of this law, and then made a few observations on the diminution of water. He had come to the conclusion that the decline of the world would be caused by want of water—rivers wearing out their beds, and the water going down into the interior of the earth never to return to the surface!

Mr. W. S. Mitchell, M.A., made some further remarks on the Denudation of the Bath Oolite. The hills of the Bath Oolite he considered to be old coral-reefs, their form not being due, as generally supposed, to denudation.

A paper by Mr. John Curry, on the general conditions of the Glacial Epoch, with suggestions on the formation of Lake-basins, concluded the meeting. The author considered that the movements of subsidence and elevation of sea-level during the glacial period were caused by the increase and diminution of a polar ice-cap.

Towards the close of the meeting, and indeed throughout most of this and the previous day, sufficient time could not be allowed for the proper consideration of the various communications. Several were deferred to the following day; but as none of the authors made their appearance, the President adjourned the reading of the papers to the next meeting of the Association. This day (Wednesday) was devoted to the celebration of the centenary anniversary of the birth of Sir Walter Scott.

Excursion to Siccar Point and Fast Castle, Berwickshire.

On Thursday morning, the 10th of August, a party of about 200 ladies and gentlemen left Edinburgh by special train for the Berwickshire coast, to examine the cliff sections, which, from the writings of Hutton, Playfair, and Hall, have become to geologists of classic interest. Leaving the train at a "siding" near Peasebridge the party soon arrived at the coast.

The first point noticed was the manner in which, at Siccar Point, the vertical and highly inclined Silurian strata are covered unconformably by the gently inclined Upper Old Red Sandstone. The Silurian strata are here seen to have been upheaved, hardened, and denuded, before the deposition of the Old Red Sandstone, which lies almost horizontally upon it, and juts out in ledges towards the sea.

Fast Castle was then visited. This old ruin stands about 80 feet above the sea on a projecting mass of rock connected with the main portion of the cliff (from which a descent of about 400 feet had been made) by a narrow ridge, and thus forms a point from which a good view of the coast is obtained. Along this wild coast-line the Lower Silurian greywacké and shales are thrown into many anticlinal and synclinal curves, extending from top to bottom of the cliffs, which are in some places more than 500 feet high, rising perpendicularly from the sea. The coast-line here cuts a section of the Lammermuir Hills; and it is from this cliff-section only that their true structure can be determined, for in the interior of the country all we see is a constant succession of rocks dipping different ways at high angles. But here is seen a continuous section of the same strata, bent round, folded over, and crumpled up into great arches, with here and there smaller or secondary folds.

St. Abb's Head, consisting, not of Silurian rocks, but of hard porphyry, and owing its existence to this fact, formed a conspicuous object in the south-west, and in the opposite direction, past Siccar Point, a long coast-line of Old Red Sandstone and Carboniferous rocks could be seen.

Mounting a bit of the old castle wall Prof. Geikie said a few words on the geological structure of the district, referring, in speaking of the classic interest of the locality, to the writings of our earliest Scottish geologists.

The party, after ascending the cliff, proceeded to Cockburnspath station, and returned by train to Edinburgh.

With this excursion the proceedings of the geological section of the British Association were brought to a close.

3. Note on the Occurrence of Peat in the Neighbourhood of Finchley.

By James T. B. Ives, Esq., F.G.S.

(Abstract.)

A bed of peat in the neighbourhood of Finchley having been observed, two sections—one at Whetstone, the other nearer Finchley, about a quarter of a mile apart—were examined, and the peat was seen to be present, and found to be identical in character at both places. There is, therefore, reason to believe that the bed extends from one place to the other, although at the Whetstone section it is six feet thick, while at the other it has a thickness of not more than one foot. The peat is covered at one place by several feet of glacial gravels, and occurs in close proximity to a bed of the Chalky Boulder Clay.*

SPECIAL GENERAL MEETING, February 2nd, 1872.

(Convened in pursuance of a duly signed Requisition, for the purpose of Adopting a Revised Code of Laws.)

The Rev. Thomas Wiltshire, M.A., F.G.S., &c., President, in the Chair.

The following Laws were separately considered, and each duly passed:—

I.—That the Society be called The Geologists' Association.

II.—That the object of the Association be to facilitate the study of Geology and its Allied Sciences by the holding of Meetings for the reading of Papers and the delivery of Lectures, by Excursions, the formation of a Library, and the publishing of Proceedings.

III.—That the Association consist of Ordinary and Honorary Members, and that Ladies be eligible for election.

IV.—That Members have the privilege of attending the Ordinary Meetings and Excursions of the Association, and of introducing two

* Subsequently to the communication of this note Professor Morris and Mr. Prestwich inspected the section so far as then exposed, and they agreed in thinking that there was not a true intercalation of the peat with the gravels, the overlying gravel, in their opinion, having been washed down from a higher level. The mere existence of surface peat in that locality may, however, interest some members, more especially as it occurs at an elevation of seventy or eighty feet above the nearest stream—the Brent—which is about a quarter of a mile distant. Mr. Carruthers was so kind as to place some of the peat under his microscope, and he concluded that it had been formed from moss which had grown in running water.

Visitors at any such Meeting or Excursion, be entitled to the use of the Library, in accordance with the Library Regulations, and to receive a copy of all publications of the Association issued during their membership.

V.—That every Candidate for admission be proposed by two or more Members, who shall sign a certificate in recommendation of such Candidate, which certificate shall set forth the name and place of residence of the Candidate.

VI.—That the Proposer whose name stands first upon the certificate have personal knowledge of the Candidate, and certify to that effect upon the certificate.

VII.—That the certificate of the Candidate be read by the Secretary at the Ordinary Meeting following the receipt of the certificate, and that the election take place at the succeeding Meeting.

VIII.—That the method of voting for the election of Members be by show of hands, unless a ballot shall have been previously demanded.

IX.—That the negative votes of one-sixth of the Members present exclude a Candidate.

X.—That the Annual Subscription for Ordinary Members be Ten Shillings (except in the case of Country Members elected previous to January, 1863).

XI.—That Members may commute the Annual Subscription by a payment of Five Pounds Five Shillings.

XII.—That Ordinary Members pay an Admission Fee of Ten Shillings.

XIII.—That subscriptions become due on the 1st of January in each year; in the case of a new Member, immediately after his or her election, but that Members elected during the months of November and December shall not be required to pay for the year in which they were elected.

XIV.—That no Member be entitled to any of the privileges of the Association whose subscription shall be twelve months in arrear; and that any Member whose Annual Subscriptions are two years in arrear may be excluded from the Association by the General Committee, and when so excluded shall cease to be a Member of the Association.

XV.—That the management of the Association be vested in a

President, four Vice-Presidents, a Treasurer, an Honorary Secretary, an Honorary Librarian, and twelve other Members, who shall constitute a General Committee, to be elected annually, by ballot if required; the retiring officers being eligible for re-election.

XVI.—That the members of the General Committee attending each meeting of such Committee sign their names in a book kept for the purpose; five members to form a quorum.

XVII.—That the General Committee be sub-divided into such sub-committees as may be desirable, and may associate ordinary Members on any such sub-committee.

XVIII.—That for the purpose of the legal protection of the property of the Association, all the funds, books, and other property of the Association be declared to be vested in three or more Members of the Association, to be appointed by the General Committee; but the General Committee shall have power, by the vote of a majority of its whole number, to sell or otherwise dispose of any duplicate specimens, books, or other property which it may not seem to them advisable to retain.

XIX.—That minutes be kept of the Meetings of the Association and of the General Committee, and that the minutes of each Meeting be read as the first business of the next ensuing Meeting of the same kind.

XX.—That the Ordinary Meetings of the Association be held on the first Friday in each month (except during the months of August, September, and October) at eight o'clock in the evening, but that the General Committee may alter the day of meeting.

XXI.—The General Committee may, whenever they think fit, and they shall, upon a Requisition signed by not less than twelve Members, convene a Special General Meeting of the Association. That one month's notice shall be given from the chair of every Special General Meeting, and a printed notice sent to each Member of the Association not less than fourteen days before such meeting, and the object stated; and no business shall be considered at such meeting except that for which it was specially convened.

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XXIII.—That in case of a vacancy arising in any office of the Association, or in the General Committee, the General Committee have power to fill up such vacancy until the next Annual General Meeting of the Association.

XXIV.—That gentlemen of eminence in geological science, or who have done some special service to the Association, may be recommended by the General Committee for election as Honorary Members at the Annual Meeting, and shall upon being elected have full privileges of membership, but that the number of Honorary Members shall not exceed twenty.

XXV.—That a copy of these Laws be delivered to each Member upon election to membership of the Association.

XXVI.—That no Law be altered, except by a majority of votes of those present at a Special General Meeting called for that purpose.

The following resolution was then put to the meeting and carried unanimously :—

"That the Laws, as now passed, be adopted as, and form the Code of Laws of the Geologists' Association."

The Special General Meeting then terminated.

ANNUAL GENERAL MEETING, February 2nd, 1872.

The Rev. Thomas Wiltshire, M.A., F.G.S., &c., President, in the Chair.

The following Report was read by the Honorary Secretary :—

Report of the General Committee for 1871.

The General Committee of the Geologists' Association have great pleasure in congratulating the Members on the continued prosperity and progress of the Association.

During the past year the Papers have equalled in interest and importance those presented to the Association during preceding years, and your Committee have peculiar satisfaction in finding that the attendance at the evening meetings has been large, and the discussions animated and interesting.

The communications on local geology, or the geology of the neighbourhood of London, have been of great interest, and will, without doubt, prove of permanent value.

The visits to the three great Museums of the Metropolis—the British Museum, the Museum of Practical Geology, and the Museum of the Royal College of Surgeons—were in each instance participated in by a large number of Members, who conspicuously indicated their appreciation of the great advantage of inspecting specimens under the guidance of Professor Morris, Mr. Etheridge, Mr. Carruthers, Mr. Henry Woodward, and Professor Tennant, who most kindly gave, at the Museums, explanatory lectures. Your Committee feel under great obligations to the authorities of these noble homes of science for their courtesy in giving facilities for the visits of the Association.

A similar lively interest on the part of the Members has been taken in the Excursions of the Association, which, during the past year have been of great value, and almost uniformly very successful. To the gentlemen who have contributed their local knowledge, and kindly acted as Directors of the several excursions, the warmest thanks of the Association are due, for to them is principally owing the success of the excursions.

Your Committee have again the pleasure of offering, on your behalf, the thanks of the Association to Professor Morris, for the great assistance he has rendered the Association by his lectures in the museum and in the field, as well as by his instructive companionship during the excursions.

To Professor Phillips, the Rev. T. G. Bonney, Professor Buckman, the Rev. P. B. Brodie, Mr. Henry Woodward, and Mr. Harry Seeley, the thanks of the Association are also eminently due.

The Excursions have enabled the Members of the Association to examine the following formations, and thereby make themselves acquainted with the Petrology and the Palæontology of these interesting groups of strata :—

NEWER PLIOCENE—Grays, Ilford, and Barnwell.
CHALK—Grays and Riddlesdown.
UPPER GREENSAND—Cambridge.
GAULT—Cambridge.
LOWER GREENSAND—Upware.
KIMMERIDGE CLAY—Shotover.
CORALLINE OOLITE—Headington and Upware.
OXFORD CLAY—Oxford.

CORNBRASH—Islip.
FOREST MARBLE—Oxfordshire.
GREAT OOLITE—Oxfordshire.
INFERIOR OOLITE—Sherborne and Ham Hill.
UPPER LIAS—South Petherton.
MIDDLE LIAS—Yeovil and South Petherton.
LOWER LIAS—Harbury and Wilmcote.
KEUPER—Warwick.

Your Committee desire to record their appreciation of the great favour shown to the Geologists' Association by the Universities of Oxford and Cambridge, in affording facilities for the inspection of the contents of those magnificent museums, the University Museum of Oxford, and the Woodwardian Museum of Cambridge.

Through the kindness of their respective owners and custodians, the following local and private museums have been inspected during the excursions :—

Dr. SPURRELL's Museum of Thames Valley Mammalian Remains.
Mr. JAMES PARKER's Museum of Reptilian Remains.
Mr. EARWAKER's Collection of Jurassic and Cretaceous Fossils.
The Rev. E. BOWER's Collection of Mesozoic Fossils.
Professor BUCKMAN's Collection of Jurassic Fossils.
Mr. T. C. MAGG's and Mr. MONK's Collections of Yeovil Fossils.
Sir ANTONIO BRADY's Collection of Thames Valley Mammalian Remains.
The Museum of the Warwickshire Natural History and Archæological Society.
The Rev. P. B. BRODIE's Collection of Insect Remains.

Your Committee have also to acknowledge, with great pleasure, the hospitality which has been abundantly offered to the Members of the Geologists' Association who have taken part in the excursions.

The Rev. T. G. Bonney of Cambridge, Professor Buckman, the Rev. E. Bower, and Mr. Maggs of Yeovil, Mr. James Parker of Oxford, Sir Antonio Brady of Stratford, and Mr. Kirshaw of Warwick, have each contributed greatly to the success and pleasure of the excursions during the past year, by their generous entertainment of our Members.

The Library has received numerous accessions, as well by donations from individual Members, as by those from metropolitan and provincial societies. Many Scientific Societies correspond and exchange publications with the Geologists' Association, and thus our Library is growing annually in value and usefulness to Members. There are two hundred and ten books now in the Library, and of that number more than a quarter have been issued to Members during the last year, showing how greatly the Library is appreciated.

The past year has been distinguished by the commencement of the publication of Quarterly "Proceedings," and three numbers have already been issued to Members. This method of publishing the papers of value read before the Association will, it is hoped, prove more satisfactory to Members than that previously adopted.

The number of Members of the Association has largely increased during the year, and your Committee have great satisfaction in seeing amongst our new names those of several gentlemen who are already eminent in the scientific world, and other names which are known to be those of earnest students of Geological Science.

It is also matter for congratulation, as attesting the widening influence of the Association, that gentlemen resident at long distances from London are seeking admission to our body, and joining in our Excursions, which thus become a means of bringing together geologists from various parts of England, who were previously personally unknown to each other, although well known as possessing great local as well as general geological knowledge.

It has appeared to your Committee desirable that the Laws of the Association should be modified and amended, to bring them into accordance with the altered position of the Association, and the present requirements of the Members. A revision of the Laws has accordingly been accomplished, and the revised code has been duly passed at a Special General Meeting of the Association.

The Financial Position of the Association is extremely satisfactory, as will be seen from an inspection of the Treasurer's Account.

Your Committee feel that they but interpret your unanimous wishes, when they tender your thanks to the Council of University College for the courteous continuance of their grant of the Library of the College for the meetings of the Association.

You will be gratified to learn that the Rev. Thomas Wiltshire, M.A., F.G.S., &c., has intimated his willingness to continue to preside over the Association for the ensuing year.

It will be apparent from the foregoing statements that the Geologists' Association has opening before it an increased sphere of usefulness, but your Committee desire the co-operation of each one of your body in their endeavours to make our Association more and more influential for the advancement and diffusion of Geological Knowledge.

The following Papers were read during the year :—

On the Geology of the Neighbourhood of Portsmouth and Ryde, by CALEB EVANS, Esq., F.G.S.

On the Range in Time of the Foraminifera, by Professor T. RUPERT JONES, F.G.S.

On the English Crags, considered in reference to the Stratigraphical Divisions indicated by their Invertebrate Fauna, by ALFRED and ROBERT BELL.

On South African Diamonds, by Professor TENNANT, F.G.S., &c.

On Relics of the Carboniferous and other Old Land Surfaces, by HENRY WOODWARD, Esq., F.G.S., F.Z.S.

On Flint, by M. HAWKINS JOHNSON, Esq., F.G.S.

On the Upper Limits of the Devonian System, by S. R. PATTISON, Esq., F.G.S.

On an Exposure of the London Clay, at Child's Hill, Hampstead, by CALEB EVANS, Esq., F.G.S.

On the Old Land Surfaces of the Globe, by Professor MORRIS, F.G.S.

On a Recent Exposure of the Glacial Drift at Finchley, by HENRY WALKER, Esq.

On the Glacial Drifts of North London, by HENRY WALKER, Esq.

On the Overlapping of several Geological Formations on the North Wales Border, by D. C. DAVIES, Esq.

Report of the Proceedings of the Geological Section of the British Association at Edinburgh, 1871, by JOHN HOPKINSON, Esq., F.G.S., F.R.M.S.

The following is a list of the Excursions of the past year:—

	Directors.
Visit to the British Museum, March 18th.	Prof. Morris, F.G.S. Henry Woodward, Esq., F.G.S., &c. William Carruthers, Esq., F.G.S., &c.
Visit to the Museum of Practical Geology, March 25th.	Prof. Morris, F.G.S. Robert Etheridge, Esq., F.G.S., &c. Prof. Tennant, F.G.S., &c.
Excursion to Cambridge and Upware, and Visit to Woodwardian Museum, April 10th and 11th.	The President. The Rev. T. G. Bonney, M.A., F.G.S. Prof. Morris, F.G.S. Harry Seeley, Esq., F.G.S.
Visit to the Hunterian Museum of the Royal College of Surgeons, April 18th.	Prof. Morris, F.G.S.
Excursion to Belvedere, and Visit to Dr. Spurrel's Museum, April 29th.	Prof. Morris, F.G.S.
Excursion to Oxford, and visit to the University Museum, May 12th.	Prof. Phillips, F.R.S., F.G.S. J. P. Earwaker, Esq.
Excursion to Grays, Essex, May 20th.	The President.
Excursion to the Yeovil District, May 29th, 30th, 31st, and June 1st.	Prof. Buckman, F.G.S., &c. J. Logan Lobley, Esq., F.G.S.
Excursion to Ilford, and visit to Sir Antonio Brady's Museum, June 17th.	Henry Woodward, Esq., F.G.S. Sir Antonio Brady, F.G.S.
Excursion to Caterham Junction and Riddlesdown, July 1st.	J. Logan Lobley, Esq., F.G.S.
Excursion to Warwickshire, and visit to the Museum of the Warwickshire Natural History and Archæological Society, July 10th and 11th.	Rev. P. B. Brodie, M.A., F.G.S. J. W. Kirshaw, Esq., F.G.S.

Your Committee recommend the following list of Officers for the year 1872 :—

PRESIDENT.
Rev. Thomas Wiltshire, M.A., F.G.S., F.R.A.S., &c.

VICE-PRESIDENTS.

John Cumming, Esq., F.G.S.	James Thorne, Esq.
Professor John Morris, F.G.S.	Henry Woodward, Esq., F.G.S., F.Z.S.

TREASURER.
William Hislop, Esq., F.R.A.S., 177, St. John Street Road, E.C., and High Street, Tunbridge Wells.

GENERAL COMMITTEE.

Caleb Evans, Esq., F.G.S.	Thomas Lovick, Esq.
John Hopkinson, Esq., F.G.S., F.R.M.S.	C. J. A. Meÿer, Esq., F.G.S.
James William Ilott, Esq.	John S. Phené, Esq., F.G.S., F.R.G.S.
M. Hawkins Johnson, Esq., F.G.S.	George Potter, Esq., F.R.M.S.
Henry Lee, Esq., F.L S., F.G.S., F.R.M.S.	Professor Tennant, F.G.S., F.R.G.S.
W. H. Leighton, Esq., F.G.S.	Henry Walker, Esq., F.G.S.

HONORARY SECRETARY.
J. Logan Lobley, F.G.S., 59, Clarendon Road, Kensington Park, W.

HONORARY LIBRARIAN.
Arthur Bott, Esq., F.G.S.

Your Committee have great pleasure in recommending for election as Honorary Members of the Geologists' Association :—

Professor John Phillips, M.A., LL.D., F.R.S., F.G.S., &c., &c., Professor of Geology in the University of Oxford.

Robert Etheridge, Esq., F.R.S., F.G.S., &c., Palæontologist to the Geological Survey of Great Britain.

The preceding Report was unanimously adopted, and the Honorary Members and the Officers for 1872, therein recommended, duly elected.

The thanks of the Association were given to the President, the Treasurer, the Honorary Secretary, the Honorary Librarian, and the Auditors, for their services, and the Annual General Meeting then terminated.

[*The Treasurer's Account is on the next page.*]

BALANCE SHEET OF RECEIPTS AND DISBURSEMENTS

For the Year ending December 31st, 1871.

Dr.

	£	s.	d.
By Balance, January 1st, 1871	58	2	6
,, Annual Subscriptions and Entrance Fees ...	97	15	0
,, Life Compositions	10	10	0
,, Sale of Publications	2	5	6
,, Interest on Stock	8	16	0
	£172	9	0

Cr.

	£	s.	d.
To Printing	41	4	11½
,, Engraving	6	12	0
,, Bookbinding	1	8	9
,, Subscription to Palæontographical Society	1	1	0
,, Gas and Attendance	6	0	0
,, Collector's Commission	1	6	8
,, Postage, Stationery, Porterage, &c.... ...	11	18	1
Balance	102	17	11½
	£172	9	0

We have this day examined the Accounts of the Treasurer of this Association, and find that a balance of £102 17s. 11½d. remained in his hands on the 31st December, 1871.

(*Signed*) HENRY DEANE, J. S. PHENÉ, } *Auditors.*

January 25*th*, 1872.

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